

WIMPs and Other Particles Searches for

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GALACTIC WIMP SEARCHES

Limits for Spin-Independent Cross Section of Dark Matter Particle (X^0) on Nucleon

Isoscalar coupling is assumed to extract the limits from those on X^0 -nuclei cross section.

For $m_{X^0} = 20$ GeV

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<1.5 \times 10^{-5}$	90	¹ ABE	13B XMAS	Xe
$<1.2 \times 10^{-7}$	90	AKIMOV	12 ZEP3	Xe
$<8 \times 10^{-6}$	90	² ANGLOHER	12 CRES	CaWO ₄
$<7 \times 10^{-9}$	90	³ ANGLOHER	12 CRES	CaWO ₄
$<7 \times 10^{-7}$	90	⁴ ARCHAMBAU	12 PICA	F (C ₄ F ₁₀)
$<7 \times 10^{-7}$	90	⁵ ARMENGAUD	12 EDE2	Ge
$<1 \times 10^{-6}$	90	⁶ BARRETO	12 DMIC	CCD
$<7 \times 10^{-6}$	90	BEHNKE	12 COUP	CF ₃ I
$<1.5 \times 10^{-6}$	90	⁷ FELIZARDO	12 SMPL	C ₂ ClF ₅
$<5 \times 10^{-5}$	90	KIM	12 KIMS	CsI
$<2.7 \times 10^{-7}$	90	⁸ AALSETH	11 CGNT	Ge
$<2.7 \times 10^{-7}$	90	⁹ AALSETH	11A CGNT	Ge
$<3 \times 10^{-6}$	90	¹⁰ AHMED	11 CDM2	Ge, inelastic
$<7 \times 10^{-8}$	90	¹¹ AHMED	11A RVUE	Ge
$<2 \times 10^{-8}$	90	¹² AHMED	11B CDM2	Ge, low threshold
$<2 \times 10^{-7}$	90	¹³ ANGLE	11 XE10	Xe
$<7 \times 10^{-8}$	90	¹⁴ APRILE	11 X100	Xe
$<2 \times 10^{-8}$	90	¹⁵ APRILE	11A X100	Xe, inelastic
$<2 \times 10^{-7}$	90	¹⁶ APRILE	11B X100	Xe
$<2 \times 10^{-7}$	90	HORN	11 ZEP3	Xe
$<1 \times 10^{-5}$	90	AHMED	10 CDM2	Ge
$<1 \times 10^{-7}$	90	¹⁷ AKERIB	10 CDM2	Si, Ge, low threshold
$<2 \times 10^{-6}$	90	APRILE	10 X100	Xe
$<4 \times 10^{-5}$	90	ARMENGAUD	10 EDE2	Ge
$<1.5 \times 10^{-7}$	90	¹⁸ FELIZARDO	10 SMPL	C ₂ ClF ₃
$<2 \times 10^{-4}$	90	AHMED	09 CDM2	Ge
$<2 \times 10^{-4}$	90	LIN	09 TEXO	Ge
		¹⁹ AALSETH	08 CGNT	Ge

¹ See their Fig. 8 for limits extending down to $m_{X^0} = 7$ GeV.

² ANGLOHER 12 observe excess events above the expected background which are consistent with X^0 with mass ~ 25 GeV (or 12 GeV) and spin-independent X^0 -nucleon cross section of 2×10^{-6} pb (or 4×10^{-5} pb).

³ Reanalysis of ANGLOHER 09 data with all three nuclides. See also BROWN 12.

⁴ See their Fig. 7 for cross section limits for m_{X^0} between 4 and 12 GeV.

⁵ See their Fig. 4 for limits extending down to $m_{X^0} = 7$ GeV.

⁶ See their Fig. 13 for cross section limits for m_{X^0} between 1.2 and 10 GeV.

⁷ See also DAHL 12 for a criticism.

⁸ See their Fig. 4 for limits extending to $m_{X^0} = 3.5$ GeV.

⁹ AALSETH 11A find indications of annual modulation of the data, the energy spectrum being compatible with X^0 mass around 8 GeV.

¹⁰ AHMED 11 search for X^0 inelastic scattering. See their Fig. 8–10 for limits.

¹¹ AHMED 11A combine CDMS and EDELWEISS data.

¹² AHMED 11B give limits on spin-independent X^0 -nucleon cross section for $m_{X^0} = 4\text{--}12$ GeV in the range $10^{-3}\text{--}10^{-5}$ pb. See their Fig. 3.

¹³ See their Fig. 3 for limits down to $m_{X^0} = 4$ GeV.

¹⁴ APRILE 11 reanalyze APRILE 10 data.

¹⁵ APRILE 11A search for X^0 inelastic scattering. See their Fig. 2 and 3 for limits.

¹⁶ HORN 11 perform detector calibration by neutrons. Earlier results are only marginally affected.

¹⁷ See their Fig. 10 and 12 for limits extending to X^0 mass of 1 GeV.

¹⁸ Superseded by AHMED 10.

¹⁹ See their Fig. 6(a) for cross section limits for m_{X^0} extending down to 2 GeV.

²⁰ See their Fig. 2 for cross section limits for m_{X^0} between 4 and 10 GeV.

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NODE=S030

NODE=S030410

NODE=S030DIX

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NODE=S030DI1

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OCCUR=2

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NODE=S030DI1;LINKAGE=AG

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NODE=S030DI1;LINKAGE=AK

NODE=S030DI1;LINKAGE=AH

NODE=S030DI1;LINKAGE=LI

NODE=S030DI1;LINKAGE=AA

For $m_{X^0} = 100 \text{ GeV}$

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<1.67 \times 10^{-6}$	90	1,2 ABBASI	12	ICCB H, solar ν
$<1.07 \times 10^{-4}$	90	1,3 ABBASI	12	ICCB H, solar ν
$<4 \times 10^{-8}$	90	AKIMOV	12	ZEP3 Xe
$<1.4 \times 10^{-6}$	90	4 ANGLOHER	12	CRES CaWO ₄
$<3 \times 10^{-9}$	90	APRILE	12	X100 Xe
$<1.6 \times 10^{-7}$	90	BEHNKE	12	COUP CF ₃ I
$<7 \times 10^{-6}$		FELIZARDO	12	SMPL C ₂ ClF ₅
$<2.5 \times 10^{-7}$	90	5 KIM	12	KIMS CsI
$<2 \times 10^{-4}$	90	AALSETH	11	CGNT Ge
		6 AHMED	11	CDM2 Ge, inelastic
$<3.3 \times 10^{-8}$	90	7 AHMED	11A	RVUE Ge
		8 AJELLO	11	FLAT
$<3 \times 10^{-8}$	90	9 APRILE	11	X100 Xe
		10 APRILE	11A	X100 Xe, inelastic
$<1 \times 10^{-8}$	90	APRILE	11B	X100 Xe
$<5 \times 10^{-8}$	90	11 ARMENGAUD	11	EDE2 Ge
		12 HORN	11	ZEP3 Xe
$<4 \times 10^{-8}$	90	AHMED	10	CDM2 Ge
$<9 \times 10^{-6}$	90	AKERIB	10	CDM2 Si, Ge, low threshold
		13 AKIMOV	10	ZEP3 Xe, inelastic
$<5 \times 10^{-8}$	90	APRILE	10	X100 Xe
$<1 \times 10^{-7}$	90	ARMENGAUD	10	EDE2 Ge
$<3 \times 10^{-5}$	90	FELIZARDO	10	SMPL C ₂ ClF ₃
$<5 \times 10^{-8}$	90	14 AHMED	09	CDM2 Ge
		15 ANGLE	09	XE10 Xe, inelastic
$<3 \times 10^{-4}$	90	LIN	09	TEXO Ge
		16 GIULIANI	05	RVUE

NODE=S030DI2

NODE=S030DI1

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1 ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0 -proton cross section.

2 The annihilation channel $X^0\bar{X}^0 \rightarrow W^+W^-$ is assumed.

3 The annihilation channel $X^0\bar{X}^0 \rightarrow b\bar{b}$ is assumed.

4 Reanalysis of ANGLOHER 09 data with all three nuclides. See also BROWN 12.

5 See their Fig. 6 for a limit on inelastically scattering X^0 for $m_{X^0} = 70 \text{ GeV}$.

6 AHMED 11 search for X^0 inelastic scattering. See their Fig. 8–10 for limits.

7 AHMED 11A combine CDMS and EDELWEISS data.

8 AJELLO 11 search for e^\pm flux from X^0 annihilations in the Sun. Models in which X^0 annihilates into an intermediate long-lived weakly interacting particles or X^0 scatters inelastically are constrained. See their Fig. 6–8 for limits.

9 APRILE 11 reanalyze APRILE 10 data.

10 APRILE 11A search for X^0 inelastic scattering. See their Fig. 2 and 3 for limits.

11 Supersedes ARMENGAUD 10. A limit on inelastic cross section is also given.

12 HORN 11 perform detector calibration by neutrons. Earlier results are only marginally affected.

13 AKIMOV 10 give cross section limits for inelastically scattering dark matter. See their Fig. 4.

14 Superseded by AHMED 10.

15 ANGLE 09 search for X^0 inelastic scattering. See their Fig. 4 for limits.

16 GIULIANI 05 analyzes the spin-independent X^0 -nucleon cross section limits with both isoscalar and isovector couplings. See their Fig. 3 and 4 for limits on the couplings.

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NODE=S030DI2;LINKAGE=AH

NODE=S030DI2;LINKAGE=AL

NODE=S030DI2;LINKAGE=GL

NODE=S030DI3

NODE=S030DI1

OCCUR=2

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<2.12 \times 10^{-7}$	90	1,2 ABBASI	12	ICCB H, solar ν
$<6.56 \times 10^{-6}$	90	1,3 ABBASI	12	ICCB H, solar ν
$<4 \times 10^{-7}$	90	AKIMOV	12	ZEP3 Xe
$<1.1 \times 10^{-5}$	90	4 ANGLOHER	12	CRES CaWO ₄
$<2 \times 10^{-8}$	90	APRILE	12	X100 Xe
$<1.2 \times 10^{-6}$	90	BEHNKE	12	COUP CF ₃ I
$<4 \times 10^{-6}$		FELIZARDO	12	SMPL C ₂ ClF ₅
$<1.5 \times 10^{-6}$	90	5 KIM	12	KIMS CsI
		6 AHMED	11	CDM2 Ge, inelastic
$<1.5 \times 10^{-7}$	90	6 AHMED	11A	RVUE Ge
$<2 \times 10^{-7}$	90	7 APRILE	11	X100 Xe
$<8 \times 10^{-8}$	90	APRILE	11B	X100 Xe
$<2 \times 10^{-7}$	90	8 ARMENGAUD	11	EDE2 Ge

NODE=S030DI3

NODE=S030DI1

OCCUR=2

$<2 \times 10^{-7}$	90	⁹ HORN	11	ZEP3	Xe
$<4 \times 10^{-7}$	90	AHMED	10	CDM2	Ge
$<6 \times 10^{-7}$	90	APRILE	10	X100	Xe
$<3.5 \times 10^{-7}$	90	ARMENGAUD	10	EDE2	Ge

¹ ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0 -proton cross section.

2 The annihilation channel $X^0 \bar{X}^0 \rightarrow W^+ W^-$ is assumed.

3 The annihilation channel $X^0 \bar{X}^0 \rightarrow b\bar{b}$ is assumed.

4 Reanalysis of ANGLOHER 09 data with all three nuclides. See also BROWN 12.

5 AHMED 11 search for X^0 inelastic scattering. See their Fig. 8–10 for limits.

6 AHMED 11A combine CDMS and EDELWEISS data.

7 APRILE 11 reanalyze APRILE 10 data.

8 Supersedes ARMENGAUD 10. A limit on inelastic cross section is also given.

9 HORN 11 perform detector calibration by neutrons. Earlier results are only marginally affected.

10 Superseded by AHMED 10.

NODE=S030DI3;LINKAGE=AI

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NODE=S030DI3;LINKAGE=AP

NODE=S030DI3;LINKAGE=RM

NODE=S030DI3;LINKAGE=HO

NODE=S030DI3;LINKAGE=AH

NODE=S030DPX

NODE=S030DP1

NODE=S030DP1

Limits for Spin-Dependent Cross Section of Dark Matter Particle (X^0) on Proton

For $m_{X^0} = 20$ GeV

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$< 3 \times 10^{-2}$	90	ARCHAMBAU..12	PICA	F (C ₄ F ₁₀)
$< 2 \times 10^{-2}$	90	BEHNKE	12	COUP CF ₃ I
< 20	90	DAW	12	DRFT F (CF ₄)
$< 7 \times 10^{-3}$		FELIZARDO	12	SMPL C ₂ ClF ₅
< 0.15	90	KIM	12	KIMS CsI
$< 1 \times 10^5$	90	¹ AHLEN	11	DMTP F (CF ₄)
< 0.1	90	¹ BEHNKE	11	COUP CF ₃ I
$< 1.5 \times 10^{-2}$	90	^{2,3} TANAKA	11	SKAM H, solar ν
< 0.2	90	ARCHAMBAU..09	PICA	F
< 4	90	LEBEDENKO	09A	ZEP3 Xe
< 0.6	90	ANGLE	08A	XE10 Xe
< 100	90	ALNER	07	ZEP2 Xe
< 1	90	LEE	07A	KIMS CsI
< 20	90	⁴ AKERIB	06	CDMS ⁷³ Ge, ²⁹ Si
< 2	90	SHIMIZU	06A	CNTR F (CaF ₂)
< 0.5	90	ALNER	05	NAIA NaI
< 1.5	90	BARNABE-HE..05	PICA	F (C ₄ F ₁₀)
< 1.5	90	GIRARD	05	SMPL F (C ₂ ClF ₅)
< 35	90	MIUCHI	03	BOLO LiF
< 30	90	TAKEDA	03	BOLO NaF

¹ Use a direction-sensitive detector.

2 The annihilation channel $X^0 \bar{X}^0 \rightarrow b\bar{b}$ is assumed.

3 TANAKA 11 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0 -proton cross section.

4 See also AKERIB 05.

NODE=S030DP1;LINKAGE=AH

NODE=S030DP1;LINKAGE=AR

NODE=S030DP1;LINKAGE=TA

NODE=S030DP1;LINKAGE=AK

NODE=S030DP2

NODE=S030DP2

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$< 7.07 \times 10^{-4}$	90	^{1,2} ABBASI	12	ICCB H, solar ν
$< 4.53 \times 10^{-2}$	90	^{1,3} ABBASI	12	ICCB H, solar ν
$< 7 \times 10^{-2}$	90	ARCHAMBAU..12	PICA	F (C ₄ F ₁₀)
$< 7 \times 10^{-3}$	90	BEHNKE	12	COUP CF ₃ I
< 1.8	90	DAW	12	DRFT F (CF ₄)
$< 9 \times 10^{-3}$		FELIZARDO	12	SMPL C ₂ ClF ₅
$< 2 \times 10^{-2}$	90	KIM	12	KIMS CsI
$< 2 \times 10^3$	90	⁴ AHLEN	11	DMTP F (CF ₄)
$< 7 \times 10^{-2}$	90	BEHNKE	11	COUP CF ₃ I
$< 2.7 \times 10^{-4}$	90	^{2,5} TANAKA	11	SKAM H, solar ν
$< 4.5 \times 10^{-3}$	90	^{3,5} TANAKA	11	SKAM H, solar ν
		⁶ FELIZARDO	10	SMPL C ₂ ClF ₃
$< 6 \times 10^3$	90	⁴ MIUCHI	10	NAGE CF ₄
< 0.4	90	ARCHAMBAU..09	PICA	F
< 0.8	90	LEBEDENKO	09A	ZEP3 Xe

OCCUR=2

OCCUR=2

< 1.0	90	ANGLE	08A	XE10	Xe
< 15	90	ALNER	07	ZEP2	Xe
< 0.2	90	LEE	07A	KIMS	Csl
< 1 $\times 10^4$	90	⁴ MIUCHI	07	NAGE	F (CF ₄)
< 5	90	⁷ AKERIB	06	CDMS	⁷³ Ge, ²⁹ Si
< 2	90	SHIMIZU	06A	CNTR	F (CaF ₂)
< 0.3	90	ALNER	05	NAIA	Nal
< 2	90	BARNABE-HE.05	PICA	F (C ₄ F ₁₀)	
<100	90	BENOIT	05	EDEL	⁷³ Ge
< 1.5	90	GIRARD	05	SMPL	F (C ₂ ClF ₅)
< 0.7	8	GIGLIANI	05A	RVUE	
	9	GIGLIANI	04	RVUE	
	10	GIGLIANI	04A	RVUE	
< 35	90	MIUCHI	03	BOLO	LiF
< 40	90	TAKEDA	03	BOLO	NaF

¹ ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0 -proton cross section.

² The annihilation channel $X^0 \bar{X}^0 \rightarrow W^+ W^-$ is assumed.

³ The annihilation channel $X^0 \bar{X}^0 \rightarrow b\bar{b}$ is assumed.

⁴ Use a direction-sensitive detector.

⁵ TANAKA 11 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0 -proton cross section.

⁶ See their Fig. 3 for limits on spin-dependent proton couplings for X^0 mass of 50 GeV.

⁷ See also AKERIB 05.

⁸ GIGLIANI 05A analyze available data and give combined limits.

⁹ GIGLIANI 04 reanalyze COLLAR 00 data and give limits for spin-dependent X^0 -proton coupling.

¹⁰ GIGLIANI 04A give limits for spin-dependent X^0 -proton couplings from existing data.

For $m_{X^0} = 1$ TeV

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 2.50×10^{-4}	90	^{1,2} ABBASI	12	ICCB	H, solar ν
< 7.86×10^{-3}	90	^{1,3} ABBASI	12	ICCB	H, solar ν
< 4×10^{-2}	90	BEHNKE	12	COUP	CF ₃ I
< 8	90	DAW	12	DRFT	F (CF ₄)
< 6×10^{-2}	90	FELIZARDO	12	SMPL	C ₂ ClF ₅
< 8×10^{-2}	90	KIM	12	KIMS	Csl
< 8×10^3	90	⁴ AHLEN	11	DMTP	F (CF ₄)
< 0.4	90	BEHNKE	11	COUP	CF ₃ I
< 2×10^{-3}	90	^{3,5} TANAKA	11	SKAM	H, solar ν
< 2×10^{-2}	90	^{2,5} TANAKA	11	SKAM	H, solar ν
< 1×10^{-3}	90	⁶ ABBASI	10	ICCB	KK dark matter
< 2×10^4	90	⁴ MIUCHI	10	NAGE	CF ₄
< 8.7×10^{-4}	90	² ABBASI	09B	ICCB	H, solar ν
< 2.2×10^{-2}	90	³ ABBASI	09B	ICCB	H, solar ν
< 3	90	ARCHAMBAU..09	PICA	F	
< 6	90	LEBEDENKO	09A	ZEP3	Xe
< 9	90	ANGLE	08A	XE10	Xe
<100	90	ALNER	07	ZEP2	Xe
< 0.8	90	LEE	07A	KIMS	Csl
< 4×10^4	90	⁴ MIUCHI	07	NAGE	F (CF ₄)
< 30	90	⁷ AKERIB	06	CDMS	⁷³ Ge, ²⁹ Si
< 1.5	90	ALNER	05	NAIA	Nal
< 15	90	BARNABE-HE.05	PICA	F (C ₄ F ₁₀)	
< 600	90	BENOIT	05	EDEL	⁷³ Ge
< 10	90	GIRARD	05	SMPL	F (C ₂ ClF ₅)
< 260	90	MIUCHI	03	BOLO	LiF
< 150	90	TAKEDA	03	BOLO	NaF

¹ ABBASI 12 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0 -proton cross section.

² The annihilation channel $X^0 \bar{X}^0 \rightarrow W^+ W^-$ is assumed.

³ The annihilation channel $X^0 \bar{X}^0 \rightarrow b\bar{b}$ is assumed.

⁴ Use a direction-sensitive detector.

⁵ TANAKA 11 search for neutrinos from the Sun arising from the pair annihilation of X^0 trapped by the Sun. The amount of X^0 depends on the X^0 -proton cross section.

⁶ ABBASI 10 search for ν_μ from annihilations of Kaluza-Klein photon dark matter in the Sun.

⁷ See also AKERIB 05.

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NODE=S030DP2;LINKAGE=AS

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OCCUR=2

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NODE=S030DP3;LINKAGE=AH

NODE=S030DP3;LINKAGE=TA

NODE=S030DP3;LINKAGE=AA

NODE=S030DP3;LINKAGE=AK

**Limits for Spin-Dependent Cross Section
of Dark Matter Particle (X^0) on Neutron**

For $m_{X^0} = 20 \text{ GeV}$

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 0.02	90	AKIMOV	12	ZEP3 Xe
	1	AHMED	11B	CDM2 Ge, low threshold
< 0.06	90	AHMED	09	CDM2 Ge
< 0.04	90	LEBEDENKO	09A	ZEP3 Xe
< 50	2	LIN	09	TEXO Ge
< 6×10^{-3}	90	ANGLE	08A	XE10 Xe
< 0.5	90	ALNER	07	ZEP2 Xe
< 25	90	LEE	07A	KIMS CsI
< 0.3	90	3 AKERIB	06	CDMS ^{73}Ge , ^{29}Si
< 30	90	SHIMIZU	06A	CNTR F (CaF ₂)
< 60	90	ALNER	05	NAIA NaI
< 20	90	BARNABE-HE.05	PICA	F (C ₄ F ₁₀)
< 10	90	BENOIT	05	EDEL ^{73}Ge
< 4	90	KLAPDOR-K...05	HDM3	^{73}Ge (enriched)
< 600	90	TAKEDA	03	BOLO NaF

1 AHMED 11B give limits on spin-dependent X^0 -neutron cross section for $m_{X^0} = 4\text{--}12 \text{ GeV}$ in the range $10^{-3}\text{--}10 \text{ pb}$. See their Fig. 3.

2 See their Fig. 6(b) for cross section limits for m_{X^0} extending down to 2 GeV.

3 See also AKERIB 05.

NODE=S030DNX

NODE=S030DN1

NODE=S030DN1

For $m_{X^0} = 100 \text{ GeV}$

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 0.01	90	AKIMOV	12	ZEP3 Xe
	1	FELIZARDO	10	SMPL C ₂ ClF ₃
< 0.02	90	AHMED	09	CDM2 Ge
< 0.01	90	LEBEDENKO	09A	ZEP3 Xe
< 100	90	LIN	09	TEXO Ge
< 0.01	90	ANGLE	08A	XE10 Xe
< 0.05	90	2 BEDNYAKOV	08	RVUE Ge
< 0.08	90	ALNER	07	ZEP2 Xe
< 6	90	LEE	07A	KIMS CsI
< 0.07	90	3 AKERIB	06	CDMS ^{73}Ge , ^{29}Si
< 30	90	SHIMIZU	06A	CNTR F (CaF ₂)
< 10	90	ALNER	05	NAIA NaI
< 30	90	BARNABE-HE.05	PICA	F (C ₄ F ₁₀)
< 0.7	90	BENOIT	05	EDEL ^{73}Ge
< 0.2	90	4 GIULIANI	05A	RVUE
< 1.5	90	KLAPDOR-K...05	HDM3	^{73}Ge (enriched)
	5	GIULIANI	04	RVUE
	6	GIULIANI	04A	RVUE
	7	MIUCHI	03	BOLO LiF
< 800	90	TAKEDA	03	BOLO NaF

1 See their Fig. 3 for limits on spin-dependent neutron couplings for X^0 mass of 50 GeV.

2 BEDNYAKOV 08 reanalyze Klapdor-Kleingrothaus 05 and BAUDIS 01 data.

3 See also AKERIB 05.

4 GIULIANI 05A analyze available data and give combined limits.

5 GIULIANI 04 analyze COLLAR 00 data and give limits for spin-dependent X^0 -neutron coupling.

6 GIULIANI 04A give limits for spin-dependent X^0 -neutron couplings from existing data.

7 MIUCHI 03 give model-independent limit for spin-dependent X^0 -proton and neutron cross sections. See their Fig. 5.

NODE=S030DN1;LINKAGE=HM

NODE=S030DN1;LINKAGE=LI

NODE=S030DN1;LINKAGE=AK

NODE=S030DN2

NODE=S030DN2

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NODE=S030DN2;LINKAGE=GN

NODE=S030DN2;LINKAGE=GI

NODE=S030DN2;LINKAGE=GU

NODE=S030DN2;LINKAGE=MI

For $m_{X^0} = 1 \text{ TeV}$

<u>VALUE (pb)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 8×10^{-2}	90	AKIMOV	12	ZEP3 Xe
< 0.2	90	AHMED	09	CDM2 Ge
< 0.1	90	LEBEDENKO	09A	ZEP3 Xe
< 0.1	90	ANGLE	08A	XE10 Xe
< 0.25	90	¹ BEDNYAKOV	08	RVUE Ge
< 0.6	90	ALNER	07	ZEP2 Xe
< 30	90	LEE	07A	KIMS CsI
< 0.5	90	² AKERIB	06	CDMS ^{73}Ge , ^{29}Si
< 40	90	ALNER	05	NAIA NaI
<200	90	BARNABE-HE.	05	PICA F (C_4F_{10})
< 4	90	BENOIT	05	EDEL ^{73}Ge
< 10	90	KLAPDOR-K...	05	HDMS ^{73}Ge (enriched)
< 4×10^3	90	TAKEDA	03	BOLO NaF

1 BEDNYAKOV 08 reanalyze Klapdor-Kleingrothaus 05 and BAUDIS 01 data.

2 See also AKERIB 05.

NODE=S030DN3
NODE=S030DN3**Cross-Section Limits for Dark Matter Particles (X^0) on Nuclei**

These limits are for weakly-interacting stable particles that may constitute the invisible mass in the galaxy. Unless otherwise noted, a local mass density of 0.3 GeV/cm^3 is assumed; see each paper for velocity distribution assumptions. In the papers the limit is given as a function of the X^0 mass. Here we list limits only for typical mass values of 20 GeV , 100 GeV , and 1 TeV . Specific limits on supersymmetric dark matter particles may be found in the Supersymmetry section.

For $m_{X^0} = 20 \text{ GeV}$

<u>VALUE (nb)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 0.08	90	¹ ANGLOHER	02	CRES Al
		² BENOIT	00	EDEL Ge
< 0.04	95	³ KLIMENTKO	98	CNTR ^{73}Ge , inel.
< 0.8		ALESSAND...	96	CNTR O
< 6		ALESSAND...	96	CNTR Te
< 0.02	90	⁴ BELLI	96	CNTR ^{129}Xe , inel.
		⁵ BELLI	96C	CNTR ^{129}Xe
< 4×10^{-3}	90	⁶ BERNABEI	96	CNTR Na
< 0.3	90	⁶ BERNABEI	96	CNTR I
< 0.2	95	⁷ SARSA	96	CNTR Na
< 0.015	90	⁸ SMITH	96	CNTR Na
< 0.05	95	⁹ GARCIA	95	CNTR Natural Ge
< 0.1	95	QUENBY	95	CNTR Na
<90	90	¹⁰ SNOWDEN-...	95	MICA ^{16}O
< 4×10^3	90	¹⁰ SNOWDEN-...	95	MICA ^{39}K
< 0.7	90	BACCI	92	CNTR Na
< 0.12	90	¹¹ REUSSER	91	CNTR Natural Ge
< 0.06	95	CALDWELL	88	CNTR Natural Ge

1 ANGLOHER 02 limit is for spin-dependent WIMP-Aluminum cross section.

2 BENOIT 00 find four event categories in Ge detectors and suggest that low-energy surface nuclear recoils can explain anomalous events reported by UKDMC and Saclay NaI experiments.

3 KLIMENTKO 98 limit is for inelastic scattering $X^0 \text{ } ^{73}\text{Ge} \rightarrow X^0 \text{ } ^{73}\text{Ge}^*$ (13.26 keV).4 BELLI 96 limit for inelastic scattering $X^0 \text{ } ^{129}\text{Xe} \rightarrow X^0 \text{ } ^{129}\text{Xe}^*$ (39.58 keV).5 BELLI 96C use background subtraction and obtain $\sigma < 150 \text{ pb}$ ($< 1.5 \text{ fb}$) (90% CL) for spin-dependent (independent) X^0 -proton cross section. The confidence level is from R. Bernabei, private communication, May 20, 1999.

6 BERNABEI 96 use pulse shape discrimination to enhance the possible signal. The limit here is from R. Bernabei, private communication, September 19, 1997.

7 SARSA 96 search for annual modulation of WIMP signal. See SARSA 97 for details of the analysis. The limit here is from M.L. Sarsa, private communication, May 26, 1997.

8 SMITH 96 use pulse shape discrimination to enhance the possible signal. A dark matter density of 0.4 GeV cm^{-3} is assumed.

9 GARCIA 95 limit is from the event rate. A weaker limit is obtained from searches for diurnal and annual modulation.

10 SNOWDEN-IFFT 95 look for recoil tracks in an ancient mica crystal. Similar limits are also given for ^{27}Al and ^{28}Si . See COLLAR 96 and SNOWDEN-IFFT 96 for discussion on potential backgrounds.

11 REUSSER 91 limit here is changed from published (0.04) after reanalysis by authors. J.L. Vuilleumier, private communication, March 29, 1996.

NODE=S030DN3;LINKAGE=BD
NODE=S030DN3;LINKAGE=AK

NODE=S030510

NODE=S030510

NODE=S030DM1
NODE=S030DM1

OCCUR=2

OCCUR=2
OCCUR=3OCCUR=2
NODE=S030DM1;LINKAGE=AL
NODE=S030DM1;LINKAGE=BNNODE=S030DM1;LINKAGE=KA
NODE=S030DM1;LINKAGE=E
NODE=S030DM1;LINKAGE=BC

NODE=S030DM1;LINKAGE=B6

NODE=S030DM1;LINKAGE=G

NODE=S030DM1;LINKAGE=D

NODE=S030DM1;LINKAGE=A

NODE=S030DM1;LINKAGE=B

NODE=S030DM1;LINKAGE=RS

For $m_{X_0} = 100 \text{ GeV}$

<u>VALUE (nb)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 0.3	90	1 ANGLOHER 2 BELLI 3 BERNABEI 4 GREEN 5 ULLIO 6 BENOIT	02 CRES 02 RVUE 02C DAMA 02 RVUE 01 RVUE 00 EDEL	AI Ge ^{129}Xe , inel.
$< 4 \times 10^{-3}$	90	7 BERNABEI 8 AMBROSIO 9 BRHLIK	00D 99 99	
$< 8 \times 10^{-3}$	95	10 KLIMENKO	98	CNTR ^{73}Ge , inel.
< 0.08	95	11 KLIMENKO	98	CNTR ^{73}Ge , inel.
< 4		ALESSAND...	96	CNTR O
< 25		ALESSAND...	96	CNTR Te
$< 6 \times 10^{-3}$	90	12 BELLI 13 BELLI	96 96C	CNTR ^{129}Xe , inel. CNTR ^{129}Xe
$< 1 \times 10^{-3}$	90	14 BERNABEI	96	CNTR Na
< 0.3	90	14 BERNABEI	96	CNTR I
< 0.7	95	15 SARSA	96	CNTR Na
< 0.03	90	16 SMITH	96	CNTR Na
< 0.8	90	16 SMITH	96	CNTR I
< 0.35	95	17 GARCIA	95	CNTR Natural Ge
< 0.6	95	QUEENBY	95	CNTR Na
< 3	95	QUEENBY	95	CNTR I
$< 1.5 \times 10^2$	90	18 SNOWDEN....	95	MICA ^{16}O
$< 4 \times 10^2$	90	18 SNOWDEN....	95	MICA ^{39}K
< 0.08	90	19 BECK	94	CNTR ^{76}Ge
< 2.5	90	BACCI	92	CNTR Na
< 3	90	BACCI	92	CNTR I
< 0.9	90	20 REUSSER	91	CNTR Natural Ge
< 0.7	95	CALDWELL	88	CNTR Natural Ge

NODE=S030DM2

NODE=S030DM2

1 ANGLOHER 02 limit is for spin-dependent WIMP-Aluminum cross section.

2 BELLI 02 discuss dependence of the extracted WIMP cross section on the assumptions of the galactic halo structure.

3 BERNABEI 02C analyze the DAMA data in the scenario in which X^0 scatters into a slightly heavier state as discussed by SMITH 01.

4 GREEN 02 discusses dependence of extracted WIMP cross section limits on the assumptions of the galactic halo structure.

5 ULLIO 01 disfavor the possibility that the BERNABEI 99 signal is due to spin-dependent WIMP coupling.

6 BENOIT 00 find four event categories in Ge detectors and suggest that low-energy surface nuclear recoils can explain anomalous events reported by UKDMC and Saclay NaI experiments.

7 BERNABEI 00D limit is for inelastic scattering $X^0 129\text{Xe} \rightarrow X^0 129\text{Xe}$ (39.58 keV).

8 AMBROSIO 99 search for upgoing muon events induced by neutrinos originating from WIMP annihilations in the Sun and Earth.

9 BRHLIK 99 discuss the effect of astrophysical uncertainties on the WIMP interpretation of the BERNABEI 99 signal.

10 KLIMENKO 98 limit is for inelastic scattering $X^0 73\text{Ge} \rightarrow X^0 73\text{Ge}^*$ (13.26 keV).11 KLIMENKO 98 limit is for inelastic scattering $X^0 73\text{Ge} \rightarrow X^0 73\text{Ge}^*$ (66.73 keV).12 BELLI 96 limit for inelastic scattering $X^0 129\text{Xe} \rightarrow X^0 129\text{Xe}^*$ (39.58 keV).13 BELLI 96C use background subtraction and obtain $\sigma < 0.35 \text{ pb}$ ($< 0.15 \text{ fb}$) (90% CL) for spin-dependent (independent) X^0 -proton cross section. The confidence level is from R. Bernabei, private communication, May 20, 1999.

14 BERNABEI 96 use pulse shape discrimination to enhance the possible signal. The limit here is from R. Bernabei, private communication, September 19, 1997.

15 SARSA 96 search for annual modulation of WIMP signal. See SARSA 97 for details of the analysis. The limit here is from M.L. Sarsa, private communication, May 26, 1997.

16 SMITH 96 use pulse shape discrimination to enhance the possible signal. A dark matter density of 0.4 GeV cm^{-3} is assumed.

17 GARCIA 95 limit is from the event rate. A weaker limit is obtained from searches for diurnal and annual modulation.

18 SNOWDEN-IFFT 95 look for recoil tracks in an ancient mica crystal. Similar limits are also given for ^{27}Al and ^{28}Si . See COLLAR 96 and SNOWDEN-IFFT 96 for discussion on potential backgrounds.19 BECK 94 uses enriched ^{76}Ge (86% purity).

20 REUSSER 91 limit here is changed from published (0.3) after reanalysis by authors. J.L. Vuilleumier, private communication, March 29, 1996.

NODE=S030DM2;LINKAGE=AL

NODE=S030DM2;LINKAGE=LB

NODE=S030DM2;LINKAGE=CC

NODE=S030DM2;LINKAGE=GA

NODE=S030DM2;LINKAGE=UL

NODE=S030DM2;LINKAGE=BN

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NODE=S030DM2;LINKAGE=BR

NODE=S030DM2;LINKAGE=KA

NODE=S030DM2;LINKAGE=KB

NODE=S030DM2;LINKAGE=E

NODE=S030DM2;LINKAGE=BC

NODE=S030DM2;LINKAGE=B6

NODE=S030DM2;LINKAGE=G

NODE=S030DM2;LINKAGE=D

NODE=S030DM2;LINKAGE=A

NODE=S030DM2;LINKAGE=B

NODE=S030DM2;LINKAGE=C

NODE=S030DM2;LINKAGE=RS

For $m_{X^0} = 1 \text{ TeV}$

<u>VALUE (nb)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 3	90	1 ANGLOHER 2 BENOIT 3 BERNABEI 4 DERBIN	02 CRES 00 EDEL 99D CNTR 99 CNTR	Al Ge SIMP SIMP
< 0.06	95	5 KLIMENKO	98 CNTR	^{73}Ge , inel.
< 0.4	95	6 KLIMENKO	98 CNTR	^{73}Ge , inel.
< 40		ALESSAND...	96 CNTR	O
< 700		ALESSAND...	96 CNTR	Te
< 0.05	90	7 BELLI	96 CNTR	^{129}Xe , inel.
< 1.5	90	8 BELLI	96 CNTR	^{129}Xe , inel.
		9 BELLI	96C CNTR	^{129}Xe
< 0.01	90	10 BERNABEI	96 CNTR	Na
< 9	90	10 BERNABEI	96 CNTR	I
< 7	95	11 SARSA	96 CNTR	Na
< 0.3	90	12 SMITH	96 CNTR	Na
< 6	90	12 SMITH	96 CNTR	I
< 6	95	13 GARCIA	95 CNTR	Natural Ge
< 8	95	QUENBY	95 CNTR	Na
< 50	95	QUENBY	95 CNTR	I
< 700	90	14 SNOWDEN-...	95 MICA	^{16}O
< 1 $\times 10^3$	90	14 SNOWDEN-...	95 MICA	^{39}K
< 0.8	90	15 BECK	94 CNTR	^{76}Ge
< 30	90	BACCI	92 CNTR	Na
< 30	90	BACCI	92 CNTR	I
< 15	90	16 REUSSER	91 CNTR	Natural Ge
< 6	95	CALDWELL	88 CNTR	Natural Ge

NODE=S030DM3

NODE=S030DM3

1 ANGLOHER 02 limit is for spin-dependent WIMP-Aluminum cross section.

2 BENOIT 00 find four event categories in Ge detectors and suggest that low-energy surface nuclear recoils can explain anomalous events reported by UKDMC and Saclay NaI experiments.

3 BERNABEI 99D search for SIMPs (Strongly Interacting Massive Particles) in the mass range 10^3 – 10^{16} GeV. See their Fig. 3 for cross-section limits.4 DERBIN 99 search for SIMPs (Strongly Interacting Massive Particles) in the mass range 10^2 – 10^{14} GeV. See their Fig. 3 for cross-section limits.5 KLIMENKO 98 limit is for inelastic scattering $X^0 73\text{Ge} \rightarrow X^0 73\text{Ge}^*$ (13.26 keV).6 KLIMENKO 98 limit is for inelastic scattering $X^0 73\text{Ge} \rightarrow X^0 73\text{Ge}^*$ (66.73 keV).7 BELLI 96 limit for inelastic scattering $X^0 129\text{Xe} \rightarrow X^0 129\text{Xe}^*$ (39.58 keV).8 BELLI 96 limit for inelastic scattering $X^0 129\text{Xe} \rightarrow X^0 129\text{Xe}^*$ (236.14 keV).9 BELLI 96C use background subtraction and obtain $\sigma < 0.7 \text{ pb}$ ($< 0.7 \text{ fb}$) (90% CL) for spin-dependent (independent) X^0 -proton cross section. The confidence level is from R. Bernabei, private communication, May 20, 1999.

10 BERNABEI 96 use pulse shape discrimination to enhance the possible signal. The limit here is from R. Bernabei, private communication, September 19, 1997.

11 SARSA 96 search for annual modulation of WIMP signal. See SARSA 97 for details of the analysis. The limit here is from M.L. Sarsa, private communication, May 26, 1997.

12 SMITH 96 use pulse shape discrimination to enhance the possible signal. A dark matter density of 0.4 GeV cm^{-3} is assumed.

13 GARCIA 95 limit is from the event rate. A weaker limit is obtained from searches for diurnal and annual modulation.

14 SNOWDEN-IFFT 95 look for recoil tracks in an ancient mica crystal. Similar limits are also given for ^{27}Al and ^{28}Si . See COLLAR 96 and SNOWDEN-IFFT 96 for discussion on potential backgrounds.15 BECK 94 uses enriched ^{76}Ge (86% purity).

16 REUSSER 91 limit here is changed from published (5) after reanalysis by authors. J.L. Vuilleumier, private communication, March 29, 1996.

NODE=S030DM3;LINKAGE=AL

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NODE=S030DM3;LINKAGE=DD

NODE=S030DM3;LINKAGE=B3

NODE=S030DM3;LINKAGE=KA

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NODE=S030DM3;LINKAGE=BC

NODE=S030DM3;LINKAGE=B6

NODE=S030DM3;LINKAGE=G

NODE=S030DM3;LINKAGE=D

NODE=S030DM3;LINKAGE=A

NODE=S030DM3;LINKAGE=B

NODE=S030DM3;LINKAGE=C

NODE=S030DM3;LINKAGE=RS

— X^0 Annihilation Cross Section —Limits are on σv for X^0 pair annihilation at threshold.

<u>VALUE (cm3s$^{-1}$)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				

< 10^{-22}	90	1 ACKERMANN 2 ACKERMANN 3 ABBASI	12 FLAT 12 FLAT 11C ICCB	Galaxy Galaxy Galactic halo, $m=1 \text{ TeV}$
< 3×10^{-25}	95	4 ABRAMOWSKI	11 HESS	Near Galactic center, $m=1 \text{ TeV}$
< 10^{-26}	95	5 ACKERMANN	11 FLAT	Satellite galaxy, $m=10 \text{ GeV}$
< 10^{-25}	95	5 ACKERMANN	11 FLAT	Satellite galaxy, $m=100 \text{ GeV}$
< 10^{-24}	95	5 ACKERMANN	11 FLAT	Satellite galaxy, $m=1 \text{ TeV}$

NODE=S030DMA

NODE=S030DMA

NODE=S030DMA

OCCUR=2

OCCUR=2

OCCUR=3

- 1** ACKERMANN 12 search for monochromatic γ from X^0 annihilation in the Milky Way. Limit on $\sigma \cdot v$ in the range 10^{-28} – $10^{-26} \text{ cm}^{-2}\text{s}^{-1}$ (95% CL) is obtained for X^0 mass between 7 and 200 GeV if X^0 annihilates into $\gamma\gamma$. The limit depends slightly on the assumed density profile of X^0 in the Galaxy. See their Table III and Fig. 15.
- 2** ACKERMANN 12 search for γ from X^0 annihilation in the Milky Way in the diffuse γ background. Limit on $\sigma \cdot v$ of $10^{-24} \text{ cm}^{-2}\text{s}^{-1}$ or larger is obtained for X^0 mass between 5 GeV and 10 TeV for various annihilation channels including W^+W^- , $b\bar{b}$, gg , e^+e^- , $\mu^+\mu^-$, $\tau^+\tau^-$. The limit depends slightly on the assumed density profile of X^0 in the Galaxy. See their Figs. 17–20.
- 3** ABBASI 11C search for ν_μ from X^0 annihilation in the outer halo of the Milky Way. The limit assumes annihilation into $\nu\nu$. See their Fig. 9 for limits with other annihilation channels.
- 4** ABRAMOWSKI 11 search for γ from X^0 annihilation near the Galactic center. The limit assumes Einasto DM density profile.
- 5** ACKERMANN 11 search for γ from X^0 annihilation in ten dwarf spheroidal satellite galaxies of the Milky Way. The limit for $m = 10$ GeV assumes annihilation into $b\bar{b}$, the others W^+W^- . See their Fig. 2 for limits with other final states. See also GERINGER-SAMETH 11 for a different analysis of the same data.

Dark Matter Particle (X^0) Production in Hadron Collisions

Searches for X^0 production in association with observable particles (γ , jets, ...) in high energy hadron collisions. If a specific form of effective interaction Lagrangian is assumed, the limits may be translated into limits on X^0 -nucleon scattering cross section.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1 AAD	13C ATLAS	$\gamma + \not{E}_T$	
2 AALTONEN	12K CDF	$t + \not{E}_T$	
3 AALTONEN	12M CDF	jet + \not{E}_T	
4 CHATRCHYAN 12AP	CMS	jet + \not{E}_T	
5 CHATRCHYAN 12T	CMS	$\gamma + \not{E}_T$	

- 1** AAD 13C search for events with a photon and missing \not{E}_T in pp collisions at $E_{\text{cm}} = 7$ TeV with $L = 4.6 \text{ fb}^{-1}$. See their Fig. 3 for translated limits on X^0 -nucleon cross section for $m = 1.$
- 2** AALTONEN 12K search for events with a top quark and missing \not{E}_T in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ TeV with $L = 7.7 \text{ fb}^{-1}$. Upper limits on $\sigma(tX^0)$ in the range 0.4–2 pb (95% CL) is given for $m_{X^0} = 0.$
- 3** AALTONEN 12M search for events with a jet and missing \not{E}_T in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ TeV with $L = 6.7 \text{ fb}^{-1}$. Upper limits on the cross section in the range 2–10 pb (90% CL) is given for $m_{X^0} = 1. See their Fig. 2 for translated limits on X^0 -nucleon cross section.$
- 4** CHATRCHYAN 12AP search for events with a jet and missing \not{E}_T in pp collisions at $E_{\text{cm}} = 7$ TeV with $L = 5.0 \text{ fb}^{-1}$. See their Fig. 4 for translated limits on X^0 -nucleon cross section for $m_{X^0} = 0.1.$
- 5** CHATRCHYAN 12T search for events with a photon and missing \not{E}_T in pp collisions at $E_{\text{cm}} = 7$ TeV with $L = 5.0 \text{ fb}^{-1}$. Upper limits on the cross section in the range 13–15 fb (90% CL) is given for $m_{X^0} = 1. See their Fig. 2 for translated limits on X^0 -nucleon cross section.$

CONCENTRATION OF STABLE PARTICLES IN MATTER

Concentration of Heavy (Charge +1) Stable Particles in Matter

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<4 \times 10^{-17}$	95	1 YAMAGATA	93 SPEC	Deep sea water, $M=5\text{--}1600 m_p$
$<6 \times 10^{-15}$	95	2 VERKERK	92 SPEC	Water, $M= 10^5$ to $3 \times 10^7 \text{ GeV}$
$<7 \times 10^{-15}$	95	2 VERKERK	92 SPEC	Water, $M= 10^4$, $6 \times 10^7 \text{ GeV}$
$<9 \times 10^{-15}$	95	2 VERKERK	92 SPEC	Water, $M= 10^8 \text{ GeV}$
$<3 \times 10^{-23}$	90	3 HEMMICK	90 SPEC	Water, $M= 1000 m_p$
$<2 \times 10^{-21}$	90	3 HEMMICK	90 SPEC	Water, $M= 5000 m_p$
$<3 \times 10^{-20}$	90	3 HEMMICK	90 SPEC	Water, $M= 10000 m_p$
$<1 \times 10^{-29}$		SMITH	82B SPEC	Water, $M= 30\text{--}400 m_p$
$<2 \times 10^{-28}$		SMITH	82B SPEC	Water, $M= 12\text{--}1000 m_p$
$<1 \times 10^{-14}$		SMITH	82B SPEC	Water, $M > 1000 m_p$
$<(0.2\text{--}1) \times 10^{-21}$		SMITH	79 SPEC	Water, $M= 6\text{--}350 m_p$

NODE=S030DMA;LINKAGE=AK

NODE=S030DMA;LINKAGE=AE

NODE=S030DMA;LINKAGE=AB

NODE=S030DMA;LINKAGE=AR

NODE=S030DMA;LINKAGE=AC

NODE=S030DMP

NODE=S030DMP

NODE=S030DMP

NODE=S030DMP;LINKAGE=GA

NODE=S030DMP;LINKAGE=AL

NODE=S030DMP;LINKAGE=AN

NODE=S030DMP;LINKAGE=CC

NODE=S030DMP;LINKAGE=CR

NODE=S030405

NODE=S030CON

NODE=S030CON

OCCUR=2

OCCUR=3

OCCUR=2

OCCUR=3

OCCUR=2

OCCUR=3

1 YAMAGATA 93 used deep sea water at 4000 m since the concentration is enhanced in deep sea due to gravity.

2 VERKERK 92 looked for heavy isotopes in sea water and put a bound on concentration of stable charged massive particle in sea water. The above bound can be translated into into a bound on charged dark matter particle (5×10^6 GeV), assuming the local density, $\rho=0.3$ GeV/cm³, and the mean velocity $\langle v \rangle=300$ km/s.

3 See HEMMICK 90 Fig. 7 for other masses 100–10000 m_p .

Concentration of Heavy Stable Particles Bound to Nuclei

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<1.2 \times 10^{-11}$	95	¹ JAVORSEK	01	SPEC Au, $M= 3$ GeV
$<6.9 \times 10^{-10}$	95	¹ JAVORSEK	01	SPEC Au, $M= 144$ GeV
$<1 \times 10^{-11}$	95	² JAVORSEK	01B	SPEC Au, $M= 188$ GeV
$<1 \times 10^{-8}$	95	² JAVORSEK	01B	SPEC Au, $M= 1669$ GeV
$<6 \times 10^{-9}$	95	² JAVORSEK	01B	SPEC Fe, $M= 188$ GeV
$<1 \times 10^{-8}$	95	² JAVORSEK	01B	SPEC Fe, $M= 647$ GeV
$<4 \times 10^{-20}$	90	³ HEMMICK	90	SPEC C, $M = 100m_p$
$<8 \times 10^{-20}$	90	³ HEMMICK	90	SPEC C, $M = 1000m_p$
$<2 \times 10^{-16}$	90	³ HEMMICK	90	SPEC C, $M = 10000m_p$
$<6 \times 10^{-13}$	90	³ HEMMICK	90	SPEC Li, $M = 1000m_p$
$<1 \times 10^{-11}$	90	³ HEMMICK	90	SPEC Be, $M = 1000m_p$
$<6 \times 10^{-14}$	90	³ HEMMICK	90	SPEC B, $M = 1000m_p$
$<4 \times 10^{-17}$	90	³ HEMMICK	90	SPEC O, $M = 1000m_p$
$<4 \times 10^{-15}$	90	³ HEMMICK	90	SPEC F, $M = 1000m_p$
$<1.5 \times 10^{-13}/\text{nucleon}$	68	⁴ NORMAN	89	SPEC $^{206}\text{Pb}X^-$
$<1.2 \times 10^{-12}/\text{nucleon}$	68	⁴ NORMAN	87	SPEC $^{56,58}\text{Fe}X^-$

1 JAVORSEK 01 search for (neutral) SIMPs (strongly interacting massive particles) bound to Au nuclei. Here M is the effective SIMP mass.

2 JAVORSEK 01B search for (neutral) SIMPs (strongly interacting massive particles) bound to Au and Fe nuclei from various origins with exposures on the earth's surface, in a satellite, heavy ion collisions, etc. Here M is the mass of the anomalous nucleus. See also JAVORSEK 02.

3 See HEMMICK 90 Fig. 7 for other masses 100–10000 m_p .

4 Bound valid up to $m_{X^-} \sim 100$ TeV.

GENERAL NEW PHYSICS SEARCHES

This subsection lists some of the search experiments which look for general signatures characteristic of new physics, independent of the framework of a specific model.

The observed events are compatible with Standard Model expectation, unless noted otherwise.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
¹ AAD	13A ATLS	$WW \rightarrow \ell\nu\ell'\nu$	
² AAD	13C ATLS	$\gamma + \cancel{E}_T$	
³ CHATRCHYAN13	CMS	$\ell^+\ell^- + \text{jets} + \cancel{E}_T$	
⁴ AAD	12C ATLS	$t\bar{t} + \cancel{E}_T$	
⁵ AALTONEN	12M CDF	jet + \cancel{E}_T	
⁶ CHATRCHYAN12AP	CMS	jet + \cancel{E}_T	
⁷ CHATRCHYAN12Q	CMS	$Z + \text{jets} + \cancel{E}_T$	
⁸ CHATRCHYAN12T	CMS	$\gamma + \cancel{E}_T$	
⁹ AAD	11S ATLS	jet + \cancel{E}_T	
¹⁰ AALTONEN	11AF CDF	$\ell^\pm\ell^\pm$	
¹¹ CHATRCHYAN11C	CMS	$\ell^+\ell^- + \text{jets} + \cancel{E}_T$	
¹² CHATRCHYAN11U	CMS	jet + \cancel{E}_T	
¹³ AALTONEN	10AF CDF	$\gamma\gamma + \ell, \cancel{E}_T$	
¹⁴ AALTONEN	09AF CDF	$\ell\gamma b\cancel{E}_T$	
¹⁵ AALTONEN	09G CDF	$\ell\ell\ell\cancel{E}_T$	

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- 1 AAD 13A search for resonant WW production in pp collisions at $E_{cm} = 7$ TeV with $L = 4.7 \text{ fb}^{-1}$.
- 2 AAD 13C search for events with a photon and missing \cancel{E}_T in pp collisions at $E_{cm} = 7$ TeV with $L = 4.6 \text{ fb}^{-1}$.
- 3 CHATRCHYAN 13 search for events with an opposite-sign lepton pair, jets, and missing E_T in pp collisions at $E_{cm} = 7$ TeV with $L = 4.98 \text{ fb}^{-1}$.
- 4 AAD 12C search for events with a $t\bar{t}$ pair and missing \cancel{E}_T in pp collisions at $E_{cm} = 7$ TeV with $L = 1.04 \text{ fb}^{-1}$.
- 5 AALTONEN 12M search for events with a jet and missing E_T in $p\bar{p}$ collisions at $E_{cm} = 1.96$ TeV with $L = 6.7 \text{ fb}^{-1}$.
- 6 CHATRCHYAN 12AP search for events with a jet and missing E_T in pp collisions at $E_{cm} = 7$ TeV with $L = 5.0 \text{ fb}^{-1}$.
- 7 CHATRCHYAN 12Q search for events with a Z , jets, and missing \cancel{E}_T in pp collisions at $E_{cm} = 7$ TeV with $L = 4.98 \text{ fb}^{-1}$.
- 8 CHATRCHYAN 12T search for events with a photon and missing \cancel{E}_T in pp collisions at $E_{cm} = 7$ TeV with $L = 5.0 \text{ fb}^{-1}$.
- 9 AAD 11S search for events with one jet and missing E_T in pp collisions at $E_{cm} = 7$ TeV with $L = 33 \text{ pb}^{-1}$.
- 10 AALTONEN 11AF search for high- p_T like-sign dileptons in $p\bar{p}$ collisions at $E_{cm} = 1.96$ TeV with $L = 6.1 \text{ fb}^{-1}$.
- 11 CHATRCHYAN 11C search for events with an opposite-sign lepton pair, jets, and missing E_T in pp collisions at $E_{cm} = 7$ TeV with $L = 34 \text{ pb}^{-1}$.
- 12 CHATRCHYAN 11U search for events with one jet and missing E_T in pp collisions at $E_{cm} = 7$ TeV with $L = 36 \text{ pb}^{-1}$.
- 13 AALTONEN 10AF search for $\gamma\gamma$ events with e , μ , τ , or missing E_T in $p\bar{p}$ collisions at $E_{cm} = 1.96$ TeV with $L = 1.1\text{--}2.0 \text{ fb}^{-1}$.
- 14 AALTONEN 09AF search for $\ell\gamma b$ events with missing E_T in $p\bar{p}$ collisions at $E_{cm} = 1.96$ TeV with $L = 1.9 \text{ fb}^{-1}$. The observed events are compatible with Standard Model expectation including $t\bar{t}\gamma$ production.
- 15 AALTONEN 09G search for $\mu\mu\mu$ and $\mu\mu e$ events with missing E_T in $p\bar{p}$ collisions at $E_{cm} = 1.96$ TeV with $L = 976 \text{ pb}^{-1}$.

LIMITS ON JET-JET RESONANCES

Heavy Particle Production Cross Section

Limits are for a particle decaying to two hadronic jets.

Units(pb)	CL%	Mass(GeV)	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<2603	95	200	1 AAD	13D ATLS	7 TeV $pp \rightarrow 2$ jets
< 44	95	400	2 CHATRCHYAN 13A	CMS	7 TeV $pp \rightarrow 2$ jets
< 7	95	600	3 CHATRCHYAN 13A	CMS	7 TeV $pp \rightarrow b\bar{b}X$
			4 AAD	12S ATLS	7 TeV $pp \rightarrow 2$ jets
			5 CHATRCHYAN 12BL	CMS	7 TeV $pp \rightarrow t\bar{t}X$
			6 AAD	11AG ATLS	7 TeV $pp \rightarrow 2$ jets
			7 AALTONEN	11M CDF	1.96 TeV $p\bar{p} \rightarrow W + 2$ jets
			8 ABAZOV	11I D0	1.96 TeV $p\bar{p} \rightarrow W + 2$ jets
			9 AAD	10 ATLS	7 TeV $pp \rightarrow 2$ jets
			10 KHACHATRY...10	CMS	7 TeV $pp \rightarrow 2$ jets
			11 ABE	99F CDF	1.8 TeV $p\bar{p} \rightarrow b\bar{b} + \text{anything}$
			12 ABE	97G CDF	1.8 TeV $p\bar{p} \rightarrow 2$ jets
			13 ABE	93G CDF	1.8 TeV $p\bar{p} \rightarrow 2$ jets
			13 ABE	93G CDF	1.8 TeV $p\bar{p} \rightarrow 2$ jets
			13 ABE	93G CDF	1.8 TeV $p\bar{p} \rightarrow 2$ jets

1 AAD 13D search for dijet resonances in pp collisions at $E_{cm} = 7$ TeV with $L = 4.8 \text{ fb}^{-1}$. The observed events are compatible with Standard Model expectation. See their Fig. 6 and Table 2 for limits on resonance cross section in the range $m = 1.0\text{--}4.0$ TeV.

2 CHATRCHYAN 13A search for qq , qg , and gg resonances in pp collisions at $E_{cm} = 7$ TeV with $L = 4.8 \text{ fb}^{-1}$. See their Fig. 3 and Table 1 for limits on resonance cross section in the range $m = 1.0\text{--}4.3$ TeV.

3 CHATRCHYAN 13A search for $b\bar{b}$ resonances in pp collisions at $E_{cm} = 7$ TeV with $L = 4.8 \text{ fb}^{-1}$. See their Fig. 8 and Table 4 for limits on resonance cross section in the range $m = 1.0\text{--}4.0$ TeV.

4 AAD 12S search for dijet resonances in pp collisions at $E_{cm} = 7$ TeV with $L = 1.0 \text{ fb}^{-1}$. See their Fig. 3 and Table 2 for limits on resonance cross section in the range $m = 0.9\text{--}4.0$ TeV.

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NODE=S030HP;LINKAGE=CT

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- 5 CHATRCHYAN 12BL search for $t\bar{t}$ resonances in $p\bar{p}$ collisions at $E_{cm} = 7$ TeV with $L = 4.4 \text{ fb}^{-1}$. See their Fig. 4 for limits on resonance cross section in the range $m = 0.5\text{--}3.0$ TeV.
- 6 AAD 11G search for dijet resonances in $p\bar{p}$ collisions at $E_{cm} = 7$ TeV with $L = 36 \text{ pb}^{-1}$. Limits on number of events for $m = 0.6\text{--}4$ TeV are given in their Table 3.
- 7 AALTONEN 11M find a peak in two jet invariant mass distribution around 140 GeV in $W + 2$ jet events in $p\bar{p}$ collisions at $E_{cm} = 1.96$ TeV with $L = 4.3 \text{ fb}^{-1}$.
- 8 ABAZOV 11I search for two-jet resonances in $W + 2$ jet events in $p\bar{p}$ collisions at $E_{cm} = 1.96$ TeV with $L = 4.3 \text{ fb}^{-1}$ and give limits $\sigma < (2.6\text{--}1.3) \text{ pb}$ (95% CL) for $m = 110\text{--}170$ GeV. The result is incompatible with AALTONEN 11M.
- 9 AAD 10 search for narrow dijet resonances in $p\bar{p}$ collisions at $E_{cm} = 7$ TeV with $L = 315 \text{ nb}^{-1}$. Limits on the cross section in the range $10\text{--}10^3 \text{ pb}$ is given for $m = 0.3\text{--}1.7$ TeV.
- 10 KHACHATRYAN 10 search for narrow dijet resonances in $p\bar{p}$ collisions at $E_{cm} = 7$ TeV with $L = 2.9 \text{ pb}^{-1}$. Limits on the cross section in the range $1\text{--}300 \text{ pb}$ is given for $m = 0.5\text{--}2.6$ TeV separately in the final states qq , qg , and gg .
- 11 ABE 99F search for narrow $b\bar{b}$ resonances in $p\bar{p}$ collisions at $E_{cm}=1.8$ TeV. Limits on $\sigma(p\bar{p} \rightarrow X + \text{anything}) \times B(X \rightarrow b\bar{b})$ in the range $3\text{--}10^3 \text{ pb}$ (95%CL) are given for $m_X=200\text{--}750$ GeV. See their Table I.
- 12 ABE 97G search for narrow dijet resonances in $p\bar{p}$ collisions with 106 pb^{-1} of data at $E_{cm} = 1.8$ TeV. Limits on $\sigma(p\bar{p} \rightarrow X + \text{anything}) \cdot B(X \rightarrow jj)$ in the range $10^4\text{--}10^{-1} \text{ pb}$ (95%CL) are given for dijet mass $m=200\text{--}1150$ GeV with both jets having $|\eta| < 2.0$ and the dijet system having $|\cos\theta^*| < 0.67$. See their Table I for the list of limits. Supersedes ABE 93G.
- 13 ABE 93G give cross section times branching ratio into light (d, u, s, c, b) quarks for $\Gamma = 0.02 M$. Their Table II gives limits for $M = 200\text{--}900$ GeV and $\Gamma = (0.02\text{--}0.2) M$.

LIMITS ON NEUTRAL PARTICLE PRODUCTION

Production Cross Section of Radiatively-Decaying Neutral Particle

VALUE (pb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<(0.043–0.17)	95	¹ ABBIENDI 00D	OPAL	$e^+e^- \rightarrow X^0 Y^0$, $X^0 \rightarrow Y^0 \gamma$
<(0.05–0.8)	95	² ABBIENDI 00D	OPAL	$e^+e^- \rightarrow X^0 X^0$, $X^0 \rightarrow Y^0 \gamma$
<(2.5–0.5)	95	³ ACKERSTAFF 97B	OPAL	$e^+e^- \rightarrow X^0 Y^0$, $X^0 \rightarrow Y^0 \gamma$
<(1.6–0.9)	95	⁴ ACKERSTAFF 97B	OPAL	$e^+e^- \rightarrow X^0 X^0$, $X^0 \rightarrow Y^0 \gamma$

¹ ABBIENDI 00D associated production limit is for $m_{X^0} = 90\text{--}188$ GeV, $m_{Y^0} = 0$ at $E_{cm} = 189$ GeV. See also their Fig. 9.

² ABBIENDI 00D pair production limit is for $m_{X^0} = 45\text{--}94$ GeV, $m_{Y^0} = 0$ at $E_{cm} = 189$ GeV. See also their Fig. 12.

³ ACKERSTAFF 97B associated production limit is for $m_{X^0} = 80\text{--}160$ GeV, $m_{Y^0} = 0$ from 10.0 pb^{-1} at $E_{cm} = 161$ GeV. See their Fig. 3(a).

⁴ ACKERSTAFF 97B pair production limit is for $m_{X^0} = 40\text{--}80$ GeV, $m_{Y^0} = 0$ from 10.0 pb^{-1} at $E_{cm} = 161$ GeV. See their Fig. 3(b).

Heavy Particle Production Cross Section

VALUE (cm ² /N)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< $10^{-36}\text{--}10^{-33}$	90		¹ ADAMS 97B	KTEV	$m = 1.2\text{--}5$ GeV
< $(4\text{--}0.3) \times 10^{-31}$	95		² GALLAS 95	TOF	$m = 0.5\text{--}20$ GeV
< 2×10^{-36}	90	0	³ AKESSON 91	CNTR	$m = 0\text{--}5$ GeV
< 2.5×10^{-35}	0		⁴ BADIER 86	BDMP	$\tau = (0.05\text{--}1.) \times 10^{-8} \text{ s}$
			⁵ GUSTAFSON 76	CNTR	$\tau > 10^{-7} \text{ s}$

¹ ADAMS 97B search for a hadron-like neutral particle produced in pN interactions, which decays into a ρ^0 and a weakly interacting massive particle. Upper limits are given for the ratio to K_L production for the mass range 1.2–5 GeV and lifetime $10^{-9}\text{--}10^{-4}$ s. See also our Light Gluino Section.

² GALLAS 95 limit is for a weakly interacting neutral particle produced in 800 GeV/c pN interactions decaying with a lifetime of $10^{-4}\text{--}10^{-8}$ s. See their Figs. 8 and 9. Similar limits are obtained for a stable particle with interaction cross section $10^{-29}\text{--}10^{-33}$ cm². See Fig. 10.

³ AKESSON 91 limit is from weakly interacting neutral long-lived particles produced in pN reaction at 450 GeV/c performed at CERN SPS. Bourquin-Gaillard formula is used

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as the production model. The above limit is for $\tau > 10^{-7}$ s. For $\tau > 10^{-9}$ s, $\sigma < 10^{-30} \text{ cm}^{-2}/\text{nucleon}$ is obtained.

4 BADIER 86 looked for long-lived particles at 300 GeV π^- beam dump. The limit applies for nonstrongly interacting neutral or charged particles with mass >2 GeV. The limit applies for particle modes, $\mu^+ \pi^-$, $\mu^+ \mu^-$, $\pi^+ \pi^- X$, $\pi^+ \pi^- \pi^\pm$ etc. See their figure 5 for the contours of limits in the mass- τ plane for each mode.

5 GUSTAFSON 76 is a 300 GeV FNAL experiment looking for heavy ($m > 2$ GeV) long-lived neutral hadrons in the M4 neutral beam. The above typical value is for $m = 3$ GeV and assumes an interaction cross section of 1 mb. Values as a function of mass and interaction cross section are given in figure 2.

Production of New Penetrating Non- ν Like States in Beam Dump

VALUE	DOCUMENT ID	TECN	COMMENT
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- • • We do not use the following data for averages, fits, limits, etc. • • •

¹ LOSECCO 81 CALO 28 GeV protons

¹ No excess neutral-current events leads to $\sigma(\text{production}) \times \sigma(\text{interaction}) \times \text{acceptance} < 2.26 \times 10^{-71} \text{ cm}^4/\text{nucleon}^2$ (CL = 90%) for light neutrals. Acceptance depends on models (0.1 to 4×10^{-4}).

LIMITS ON CHARGED PARTICLES IN $e^+ e^-$

Heavy Particle Production Cross Section in $e^+ e^-$

Ratio to $\sigma(e^+ e^- \rightarrow \mu^+ \mu^-)$ unless noted. See also entries in Free Quark Search and Magnetic Monopole Searches.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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- • • We do not use the following data for averages, fits, limits, etc. • • •

$< 2 \times 10^{-5}$	95		¹ ACKERSTAFF 98P	OPAL	$Q=1,2/3, m=45-89.5$ GeV
$< 1 \times 10^{-5}$	95		² ABREU	97D DLPH	$Q=1,2/3, m=45-84$ GeV
$< 2 \times 10^{-3}$	90		³ BARATE	97K ALEP	$Q=1, m=45-85$ GeV
$<(10^{-2}-1)$	95		⁴ AKERS	95R OPAL	$Q=1, m=5-45$ GeV
$< 7 \times 10^{-2}$	90		⁴ AKERS	95R OPAL	$Q=2, m=5-45$ GeV
$< 1.6 \times 10^{-2}$	95	0	⁵ BUSKULIC	93C ALEP	$Q=1, m=32-72$ GeV
$< 5.0 \times 10^{-2}$	90	0	⁶ ADACHI	90C TOPZ	$Q = 1, m = 1-16,$ $18-27$ GeV
			⁷ ADACHI	90E TOPZ	$Q = 1, m = 5-25$ GeV
			⁸ KINOSHITA	82 PLAS	$Q=3-180, m < 14.5$ GeV
			⁹ BARTEL	80 JADE	$Q=(3,4,5)/3$ 2-12 GeV

¹ ACKERSTAFF 98P search for pair production of long-lived charged particles at E_{cm} between 130 and 183 GeV and give limits $\sigma < (0.05-0.2)$ pb (95%CL) for spin-0 and spin-1/2 particles with $m=45-89.5$ GeV, charge 1 and 2/3. The limit is translated to the cross section at $E_{\text{cm}}=183$ GeV with the s dependence described in the paper. See their Figs. 2-4.

² ABREU 97D search for pair production of long-lived particles and give limits $\sigma < (0.4-2.3)$ pb (95%CL) for various center-of-mass energies $E_{\text{cm}}=130-136, 161$, and 172 GeV, assuming an almost flat production distribution in $\cos\theta$.

³ BARATE 97K search for pair production of long-lived charged particles at $E_{\text{cm}} = 130, 136, 161$, and 172 GeV and give limits $\sigma < (0.2-0.4)$ pb (95%CL) for spin-0 and spin-1/2 particles with $m=45-85$ GeV. The limit is translated to the cross section at $E_{\text{cm}}=172$ GeV with the E_{cm} dependence described in the paper. See their Figs. 2 and 3 for limits on $J = 1/2$ and $J = 0$ cases.

⁴ AKERS 95R is a CERN-LEP experiment with $W_{\text{cm}} \sim m_Z$. The limit is for the production of a stable particle in multihadron events normalized to $\sigma(e^+ e^- \rightarrow \text{hadrons})$. Constant phase space distribution is assumed. See their Fig. 3 for bounds for $Q = \pm 2/3, \pm 4/3$.

⁵ BUSKULIC 93C is a CERN-LEP experiment with $W_{\text{cm}} = m_Z$. The limit is for a pair or single production of heavy particles with unusual ionization loss in TPC. See their Fig. 5 and Table 1.

⁶ ADACHI 90C is a KEK-TRISTAN experiment with $W_{\text{cm}} = 52-60$ GeV. The limit is for pair production of a scalar or spin-1/2 particle. See Figs. 3 and 4.

⁷ ADACHI 90E is KEK-TRISTAN experiment with $W_{\text{cm}} = 52-61.4$ GeV. The above limit is for inclusive production cross section normalized to $\sigma(e^+ e^- \rightarrow \mu^+ \mu^-) \cdot \beta(3 - \beta^2)/2$, where $\beta = (1 - 4m^2/W_{\text{cm}}^2)^{1/2}$. See the paper for the assumption about the production mechanism.

⁸ KINOSHITA 82 is SLAC PEP experiment at $W_{\text{cm}} = 29$ GeV using lexan and ^{39}Cr plastic sheets sensitive to highly ionizing particles.

⁹ BARTEL 80 is DESY-PETRA experiment with $W_{\text{cm}} = 27-35$ GeV. Above limit is for inclusive pair production and ranges between 1×10^{-1} and 1×10^{-2} depending on mass and production momentum distributions. (See their figures 9, 10, 11).

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Branching Fraction of Z^0 to a Pair of Stable Charged Heavy Fermions

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<5 \times 10^{-6}$	95	¹ AKERS	95R OPAL	$m = 40.4\text{--}45.6 \text{ GeV}$
$<1 \times 10^{-3}$	95	AKRAWY	900 OPAL	$m = 29\text{--}40 \text{ GeV}$
¹ AKERS 95R give the 95% CL limit $\sigma(X\bar{X})/\sigma(\mu\bar{\mu}) < 1.8 \times 10^{-4}$ for the pair production of singly- or doubly-charged stable particles. The limit applies for the mass range 40.4–45.6 GeV for X^\pm and $< 45.6 \text{ GeV}$ for $X^{\pm\pm}$. See the paper for bounds for $Q = \pm 2/3, \pm 4/3$.				

LIMITS ON CHARGED PARTICLES IN HADRONIC REACTIONS

Heavy Particle Production Cross Section

VALUE (nb)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<1.2 \times 10^{-3}$	95	¹ AAD	11I ATLS	$ q =10e, m=0.2\text{--}1 \text{ TeV}$
$<1.0 \times 10^{-5}$	95	^{2,3} AALTONEN	09Z CDF	$m>100 \text{ GeV, noncolored}$
$<4.8 \times 10^{-5}$	95	^{2,4} AALTONEN	09Z CDF	$m>100 \text{ GeV, colored}$
$<0.31\text{--}0.04 \times 10^{-3}$	95	⁵ ABAZOV	09M D0	pair production
<0.19	95	⁶ AKTAS	04C H1	$m=3\text{--}10 \text{ GeV}$
<0.05	95	⁷ ABE	92J CDF	$m=50\text{--}200 \text{ GeV}$
$<30\text{--}130$		⁸ CARROLL	78 SPEC	$m=2\text{--}2.5 \text{ GeV}$
<100		⁹ LEIPUNER	73 CNTR	$m=3\text{--}11 \text{ GeV}$

¹ AAD 11I search for production of highly ionizing massive particles in $p\bar{p}$ collisions at $E_{\text{cm}} = 7 \text{ TeV}$ with $L = 3.1 \text{ pb}^{-1}$. See their Table 5 for similar limits for $|q| = 6e$ and 17e, Table 6 for limits on pair production cross section.

² AALTONEN 09Z search for long-lived charged particles in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ with $L = 1.0 \text{ fb}^{-1}$. The limits are on production cross section for a particle of mass above 100 GeV in the region $|\eta| \lesssim 0.7$, $p_T > 40 \text{ GeV}$, and $0.4 < \beta < 1.0$.

³ Limit for weakly interacting charge-1 particle.

⁴ Limit for up-quark like particle.

⁵ ABAZOV 09M search for pair production of long-lived charged particles in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ with $L = 1.1 \text{ fb}^{-1}$. Limit on the cross section of $(0.31\text{--}0.04) \text{ pb}$ (95% CL) is given for the mass range of 60–300 GeV, assuming the kinematics of stau pair production.

⁶ AKTAS 04C look for charged particle photoproduction at HERA with mean c.m. energy of 200 GeV.

⁷ ABE 92J look for pair production of unit-charged particles which leave detector before decaying. Limit shown here is for $m = 50 \text{ GeV}$. See their Fig. 5 for different charges and stronger limits for higher mass.

⁸ CARROLL 78 look for neutral, $S = -2$ dihyperon resonance in $p\bar{p} \rightarrow 2K^+X$. Cross section varies within above limits over mass range and $p_{\text{lab}} = 5.1\text{--}5.9 \text{ GeV}/c$.

⁹ LEIPUNER 73 is an NAL 300 GeV p experiment. Would have detected particles with lifetime greater than 200 ns.

Heavy Particle Production Differential Cross Section

VALUE ($\text{cm}^2\text{sr}^{-1}\text{GeV}^{-1}$)	CL%	DOCUMENT ID	TECN	CHG	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<2.6 \times 10^{-36}$	90	¹ BALDIN	76 CNTR	–	$Q = 1, m = 2.1\text{--}9.4 \text{ GeV}$
$<2.2 \times 10^{-33}$	90	² ALBROW	75 SPEC	±	$Q = \pm 1, m = 4\text{--}15 \text{ GeV}$
$<1.1 \times 10^{-33}$	90	² ALBROW	75 SPEC	±	$Q = \pm 2, m = 6\text{--}27 \text{ GeV}$
$<8. \times 10^{-35}$	90	³ JOVANOV...	75 CNTR	±	$m = 15\text{--}26 \text{ GeV}$
$<1.5 \times 10^{-34}$	90	³ JOVANOV...	75 CNTR	±	$Q = \pm 2, m = 3\text{--}10 \text{ GeV}$
$<6. \times 10^{-35}$	90	³ JOVANOV...	75 CNTR	±	$Q = \pm 2, m = 10\text{--}26 \text{ GeV}$
$<1. \times 10^{-31}$	90	⁴ APPEL	74 CNTR	±	$m = 3.2\text{--}7.2 \text{ GeV}$
$<5.8 \times 10^{-34}$	90	⁵ ALPER	73 SPEC	±	$m = 1.5\text{--}24 \text{ GeV}$
$<1.2 \times 10^{-35}$	90	⁶ ANTIPOV	71B CNTR	–	$Q = -, m = 2.2\text{--}2.8$
$<2.4 \times 10^{-35}$	90	⁷ ANTIPOV	71C CNTR	–	$Q = -, m = 1.2\text{--}1.7, 2.1\text{--}4$
$<2.4 \times 10^{-35}$	90	BINON	69 CNTR	–	$Q = -, m = 1\text{--}1.8 \text{ GeV}$
$<1.5 \times 10^{-36}$		⁸ DORFAN	65 CNTR		Be target $m = 3\text{--}7 \text{ GeV}$
$<3.0 \times 10^{-36}$		⁸ DORFAN	65 CNTR		Fe target $m = 3\text{--}7 \text{ GeV}$

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OCCUR=3

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- ¹BALDIN 76 is a 70 GeV Serpukhov experiment. Value is per Al nucleus at $\theta = 0$. For other charges in range -0.5 to -3.0 , CL = 90% limit is $(2.6 \times 10^{-36}) / |(\text{charge})|$ for mass range (2.1–9.4 GeV) $\times |(\text{charge})|$. Assumes stable particle interacting with matter as do antiprotons.
- ²ALBROW 75 is a CERN ISR experiment with $E_{\text{cm}} = 53$ GeV. $\theta = 40$ mr. See figure 5 for mass ranges up to 35 GeV.
- ³JOVANOVICH 75 is a CERN ISR 26+26 and 15+15 GeV $p p$ experiment. Figure 4 covers ranges $Q = 1/3$ to 2 and $m = 3$ to 26 GeV. Value is per GeV momentum.
- ⁴APPEL 74 is NAL 300 GeV $p W$ experiment. Studies forward production of heavy (up to 24 GeV) charged particles with momenta 24–200 GeV (−charge) and 40–150 GeV (+charge). Above typical value is for 75 GeV and is per GeV momentum per nucleon.
- ⁵ALPER 73 is CERN ISR 26+26 GeV $p p$ experiment. $p > 0.9$ GeV, $0.2 < \beta < 0.65$.
- ⁶ANTIPOV 71B is from same 70 GeV p experiment as ANTIPOV 71C and BINON 69.
- ⁷ANTIPOV 71C limit inferred from flux ratio. 70 GeV p experiment.
- ⁸DORFAN 65 is a 30 GeV/c p experiment at BNL. Units are per GeV momentum per nucleus.

Long-Lived Heavy Particle Invariant Cross Section

VALUE ($\text{cm}^2/\text{GeV}^2/N$)	CL%	DOCUMENT ID	TECN	CHG	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 5–700 $\times 10^{-35}$	90	¹ BERNSTEIN	88	CNTR	
< 5–700 $\times 10^{-37}$	90	¹ BERNSTEIN	88	CNTR	
< 2.5 $\times 10^{-36}$	90	² THRON	85	CNTR	$Q = 1, m = 4\text{--}12$ GeV
< 1. $\times 10^{-35}$	90	² THRON	85	CNTR	$Q = 1, m = 4\text{--}12$ GeV
< 6. $\times 10^{-33}$	90	³ ARMITAGE	79	SPEC	$m = 1.87$ GeV
< 1.5 $\times 10^{-33}$	90	³ ARMITAGE	79	SPEC	$m = 1.5\text{--}3.0$ GeV
		⁴ BOZZOLI	79	CNTR	$Q = (2/3, 1, 4/3, 2)$
< 1.1 $\times 10^{-37}$	90	⁵ CUTTS	78	CNTR	$m = 4\text{--}10$ GeV
< 3.0 $\times 10^{-37}$	90	⁶ VIDAL	78	CNTR	$m = 4.5\text{--}6$ GeV

- ¹BERNSTEIN 88 limits apply at $x = 0.2$ and $p_T = 0$. Mass and lifetime dependence of limits are shown in the regions: $m = 1.5\text{--}7.5$ GeV and $\tau = 10^{-8}\text{--}2 \times 10^{-6}$ s. First number is for hadrons; second is for weakly interacting particles.
- ²THRON 85 is FNAL 400 GeV proton experiment. Mass determined from measured velocity and momentum. Limits are for $\tau > 3 \times 10^{-9}$ s.
- ³ARMITAGE 79 is CERN-ISR experiment at $E_{\text{cm}} = 53$ GeV. Value is for $x = 0.1$ and $p_T = 0.15$. Observed particles at $m = 1.87$ GeV are found all consistent with being antideuterons.
- ⁴BOZZOLI 79 is CERN-SPS 200 GeV $p N$ experiment. Looks for particle with τ larger than 10^{-8} s. See their figure 11–18 for production cross-section upper limits vs mass.
- ⁵CUTTS 78 is p Be experiment at FNAL sensitive to particles of $\tau > 5 \times 10^{-8}$ s. Value is for $-0.3 < x < 0$ and $p_T = 0.175$.
- ⁶VIDAL 78 is FNAL 400 GeV proton experiment. Value is for $x = 0$ and $p_T = 0$. Puts lifetime limit of $< 5 \times 10^{-8}$ s on particle in this mass range.

Long-Lived Heavy Particle Production ($\sigma(\text{Heavy Particle}) / \sigma(\pi)$)

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 10 ⁻⁸	1	NAKAMURA 89	SPEC	±	$Q = (-5/3, \pm 2)$
0	2	BUSSIÈRE 80	CNTR	±	$Q = (2/3, 1, 4/3, 2)$

- ¹NAKAMURA 89 is KEK experiment with 12 GeV protons on Pt target. The limit applies for mass $\lesssim 1.6$ GeV and lifetime $\gtrsim 10^{-7}$ s.
- ²BUSSIÈRE 80 is CERN-SPS experiment with 200–240 GeV protons on Be and Al target. See their figures 6 and 7 for cross-section ratio vs mass.

Production and Capture of Long-Lived Massive Particles

VALUE (10^{-36} cm^2)	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 20 to 800	0	¹ ALEKSEEV 76	ELEC	$\tau = 5$ ms to 1 day
< 200 to 2000	0	¹ ALEKSEEV 76B	ELEC	$\tau = 100$ ms to 1 day
< 1.4 to 9	0	² FRANKEL 75	CNTR	$\tau = 50$ ms to 10 hours
< 0.1 to 9	0	³ FRANKEL 74	CNTR	$\tau = 1$ to 1000 hours

- ¹ALEKSEEV 76 and ALEKSEEV 76B are 61–70 GeV p Serpukhov experiment. Cross section is per Pb nucleus.
- ²FRANKEL 75 is extension of FRANKEL 74.
- ³FRANKEL 74 looks for particles produced in thick Al targets by 300–400 GeV/c protons.

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NODE=S030CA;LINKAGE=B

NODE=S030CA;LINKAGE=A

Long-Lived Particle Search at Hadron Collisions

Limits are for cross section times branching ratio.

VALUE (pb/nucleon)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2	90	0	1 BADIER	86	BDMP $\tau = (0.05-1.) \times 10^{-8}$ s

1 BADIER 86 looked for long-lived particles at 300 GeV π^- beam dump. The limit applies for nonstrongly interacting neutral or charged particles with mass > 2 GeV. The limit applies for particle modes, $\mu^+ \pi^-$, $\mu^+ \mu^-$, $\pi^+ \pi^- X$, $\pi^+ \pi^- \pi^\pm$ etc. See their figure 5 for the contours of limits in the mass- τ plane for each mode.

Long-Lived Heavy Particle Cross Section

VALUE (pb/sr)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<34	95	1 RAM	94	SPEC $1015 < m_{X^{++}} < 1085$ MeV
<75	95	1 RAM	94	SPEC $920 < m_{X^{++}} < 1025$ MeV

1 RAM 94 search for a long-lived doubly-charged fermion X^{++} with mass between m_N and $m_N + m_\pi$ and baryon number +1 in the reaction $p p \rightarrow X^{++} n$. No candidate is found. The limit is for the cross section at 15° scattering angle at 460 MeV incident energy and applies for $\tau(X^{++}) \gg 0.1 \mu s$.

LIMITS ON CHARGED PARTICLES IN COSMIC RAYS

Heavy Particle Flux in Cosmic Rays

VALUE (cm $^{-2}$ sr $^{-1}$ s $^{-1}$)	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$\sim 6 \times 10^{-9}$	2	1 SAITO	90			$Q \simeq 14, m \simeq 370 m_p$
$< 1.4 \times 10^{-12}$	90	0	2 MINCER	85	CALO	$m \geq 1$ TeV
			3 SAKUYAMA	83B	PLAS	$m \sim 1$ TeV
$< 1.7 \times 10^{-11}$	99	0	4 BHAT	82	CC	
$< 1. \times 10^{-9}$	90	0	5 MARINI	82	CNTR \pm	$Q=1, m \sim 4.5 m_p$
$2. \times 10^{-9}$	3	6 YOCK	81	SPRK \pm		$Q=1, m \sim 4.5 m_p$
						Fractionally charged
3.0×10^{-9}	3	6 YOCK	81	SPRK		$m \sim 4.5 m_p$
$(4 \pm 1) \times 10^{-11}$	3	GOODMAN	79	ELEC		$m \geq 5$ GeV
$< 1.3 \times 10^{-9}$	90	8 BHAT	78	CNTR \pm		$m > 1$ GeV
$< 1.0 \times 10^{-9}$	0	BRIATORE	76	ELEC		
$< 7. \times 10^{-10}$	90	YOCK	75	ELEC \pm		$Q > 7e$ or $< -7e$
$> 6. \times 10^{-9}$	5	9 YOCK	74	CNTR		$m > 6$ GeV
$< 3.0 \times 10^{-8}$	0	DARDO	72	CNTR		
$< 1.5 \times 10^{-9}$	0	TONWAR	72	CNTR		$m > 10$ GeV
$< 3.0 \times 10^{-10}$	0	BJORNBOE	68	CNTR		$m > 5$ GeV
$< 5.0 \times 10^{-11}$	90	JONES	67	ELEC		$m=5-15$ GeV

1 SAITO 90 candidates carry about 450 MeV/nucleon. Cannot be accounted for by conventional backgrounds. Consistent with strange quark matter hypothesis.

2 MINCER 85 is high statistics study of calorimeter signals delayed by 20–200 ns. Calibration with AGS beam shows they can be accounted for by rare fluctuations in signals from low-energy hadrons in the shower. Claim that previous delayed signals including BJORNBOE 68, DARDO 72, BHAT 82, SAKUYAMA 83B below may be due to this fake effect.

3 SAKUYAMA 83B analyzed 6000 extended air shower events. Increase of delayed particles and change of lateral distribution above 10^{17} eV may indicate production of very heavy parent at top of atmosphere.

4 BHAT 82 observed 12 events with delay $> 2 \times 10^{-8}$ s and with more than 40 particles. 1 eV has good hadron shower. However all events are delayed in only one of two detectors in cloud chamber, and could not be due to strongly interacting massive particle.

5 MARINI 82 applied PEP-counter for TOF. Above limit is for velocity = 0.54 of light. Limit is inconsistent with YOCK 80 YOCK 81 events if isotropic dependence on zenith angle is assumed.

6 YOCK 81 saw another 3 events with $Q = \pm 1$ and m about $4.5 m_p$ as well as 2 events with $m > 5.3 m_p$, $Q = \pm 0.75 \pm 0.05$ and $m > 2.8 m_p$, $Q = \pm 0.70 \pm 0.05$ and 1 event with $m = (9.3 \pm 3.) m_p$, $Q = \pm 0.89 \pm 0.06$ as possible heavy candidates.

7 YOCK 80 events are with charge exactly or approximately equal to unity.

8 BHAT 78 is at Kolar gold fields. Limit is for $\tau > 10^{-6}$ s.

9 YOCK 74 events could be tritons.

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NODE=S030F;LINKAGE=A

Superheavy Particle (Quark Matter) Flux in Cosmic Rays

VALUE (cm ⁻² sr ⁻¹ s ⁻¹)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<5 × 10 ⁻¹⁶	90		¹ AMBROSIO 00B	MCRO	$m > 5 \times 10^{14}$ GeV
<1.8 × 10 ⁻¹²	90		² ASTONE 93	CNTR	$m \geq 1.5 \times 10^{-13}$ gram
<1.1 × 10 ⁻¹⁴	90		³ AHLEN 92	MCRO	$10^{-10} < m < 0.1$ gram
<2.2 × 10 ⁻¹⁴	90	0	⁴ NAKAMURA 91	PLAS	$m > 10^{11}$ GeV
<6.4 × 10 ⁻¹⁶	90	0	⁵ ORITO 91	PLAS	$m > 10^{12}$ GeV
<2.0 × 10 ⁻¹¹	90		⁶ LIU 88	BOLO	$m > 1.5 \times 10^{-13}$ gram
<4.7 × 10 ⁻¹²	90		⁷ BARISH 87	CNTR	$1.4 \times 10^8 < m < 10^{12}$ GeV
<3.2 × 10 ⁻¹¹	90	0	⁸ NAKAMURA 85	CNTR	$m > 1.5 \times 10^{-13}$ gram
<3.5 × 10 ⁻¹¹	90	0	⁹ ULLMAN 81	CNTR	Planck-mass 10^{19} GeV
<7. × 10 ⁻¹¹	90	0	⁹ ULLMAN 81	CNTR	$m \leq 10^{16}$ GeV

- ¹ AMBROSIO 00B searched for quark matter ("nuclearites") in the velocity range $(10^{-5}-1)$ c. The listed limit is for 2×10^{-3} c.
- ² ASTONE 93 searched for quark matter ("nuclearites") in the velocity range $(10^{-3}-1)$ c. Their Table 1 gives a compilation of searches for nuclearites.
- ³ AHLEN 92 searched for quark matter ("nuclearites"). The bound applies to velocity $< 2.5 \times 10^{-3}$ c. See their Fig. 3 for other velocity/c and heavier mass range.
- ⁴ NAKAMURA 91 searched for quark matter in the velocity range $(4 \times 10^{-5}-1)$ c.
- ⁵ ORITO 91 searched for quark matter. The limit is for the velocity range $(10^{-4}-10^{-3})$ c.
- ⁶ LIU 88 searched for quark matter ("nuclearites") in the velocity range $(2.5 \times 10^{-3}-1)$ c. A less stringent limit of 5.8×10^{-11} applies for $(1-2.5) \times 10^{-3}$ c.
- ⁷ BARISH 87 searched for quark matter ("nuclearites") in the velocity range $(2.7 \times 10^{-4}-5 \times 10^{-3})$ c.
- ⁸ NAKAMURA 85 at KEK searched for quark-matter. These might be lumps of strange quark matter with roughly equal numbers of u, d, s quarks. These lumps or nuclearites were assumed to have velocity of $(10^{-4}-10^{-3})$ c.
- ⁹ ULLMAN 81 is sensitive for heavy slow singly charge particle reaching earth with vertical velocity 100–350 km/s.

Highly Ionizing Particle Flux

VALUE (m ⁻² yr ⁻¹)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.4	95	0	KINOSHITA 81B	PLAS	Z/β 30–100

SEARCHES FOR QUANTUM BLACK HOLE PRODUCTION

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
¹ AAD 13D	ATLS	7 TeV $p p \rightarrow$ 2 jets	
² CHATRCHYAN 13A	CMS	7 TeV $p p \rightarrow$ 2 jets	
³ CHATRCHYAN 12W	CMS	7 TeV $p p \rightarrow$ multijets	
⁴ AAD	11AG ATLS	7 TeV $p p \rightarrow$ 2 jets	

- ¹ AAD 13D search for quantum black hole formation followed by its decay to two jets, in $p p$ collisions at $E_{cm} = 7$ TeV with $L = 4.8$ fb⁻¹. See their Fig. 8 and Table 3 for limits.
- ² CHATRCHYAN 13A search for quantum black hole formation followed by its decay to two jets, in $p p$ collisions at $E_{cm} = 7$ TeV with $L = 5$ fb⁻¹. See their Figs. 5 and 6 for limits.
- ³ CHATRCHYAN 12W search for quantum black hole formation followed by its evaporation to multiparticle final states, in multijet (including γ , ℓ) events in $p p$ collisions at $E_{cm} = 7$ TeV with $L = 4.7$ fb⁻¹. See their Figs. 5–8 for limits.
- ⁴ AAD 11AG search for quantum black hole formation followed by its decay to two jets, in $p p$ collisions at $E_{cm} = 7$ TeV with $L = 36$ pb⁻¹. See their Fig. 11 and Table 4 for limits.

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NODE=S030BHP

NODE=S030BHP;LINKAGE=GA

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NODE=S030BHP;LINKAGE=CH

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REFERENCES FOR Searches for WIMPs and Other Particles

				NODE=S030
AAD	13A	PL B718 860	G. Aad <i>et al.</i>	REFID=54789
AAD	13C	PRL 110 011802	G. Aad <i>et al.</i>	REFID=54791
AAD	13D	JHEP 1301 029	G. Aad <i>et al.</i>	REFID=54792
ABE	13B	PL B719 78	K. Abe <i>et al.</i>	(XMASS Collab.) REFID=54922
CHATRCHYAN	13	PL B718 815	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=54769
CHATRCHYAN	13A	JHEP 1301 013	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=54770
AAD	12C	PRL 108 041805	G. Aad <i>et al.</i>	(ATLAS Collab.) REFID=54080
AAD	12S	PL B708 37	G. Aad <i>et al.</i>	(ATLAS Collab.) REFID=54152
AALTONEN	12K	PRL 108 201802	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=54240
AALTONEN	12M	PRL 108 211804	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=54242
ABBASI	12	PR D85 042002	R. Abbasi <i>et al.</i>	(IceCube Collab.) REFID=54487
ACKERMANN	12	PR D86 022002	M. Ackermann <i>et al.</i>	(Fermi-LAT Colab.) REFID=54422
AKIMOV	12	PL B709 14	D.Yu. Akimov <i>et al.</i>	(ZEPLIN-III Collab.) REFID=54153
ANGLOHER	12	EPJ C72 1971	G. Angloher <i>et al.</i>	(CREST-II Collab.) REFID=54137
APRILE	12	PRL 109 181301	E. Aprile <i>et al.</i>	(XENON100 Collab.) REFID=54616
ARCHAMBAU...	12	PL B711 153	S. Archambault <i>et al.</i>	(PICASSO Collab.) REFID=54166
ARMENGAUD	12	PR D86 051701	E. Armengaud <i>et al.</i>	(EDELWEISS Collab.) REFID=54609
BARRETO	12	PL B711 264	J. Barreto <i>et al.</i>	(DAMIC Collab.) REFID=54169
BEHNKE	12	PR D86 052001	E. Behnke <i>et al.</i>	(COUPP Collab.) REFID=54610
BROWN	12	PR D85 021301	A. Brown <i>et al.</i>	(OXF) REFID=54390
CHATRCHYAN	12AP	JHEP 1209 094	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=54572
CHATRCHYAN	12BL	JHEP 1212 015	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=54776
CHATRCHYAN	12Q	PL B716 260	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=54184
CHATRCHYAN	12T	PRL 108 261803	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=54251
CHATRCHYAN	12W	JHEP 1204 061	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=54459
DAHL	12	PRL 108 259001	C.E. Dahl, J. Hall, W.H. Lippincott	(CHIC, FNAL) REFID=54992
DAW	12	ASP 35 397	E. Daw <i>et al.</i>	(DRIFT-IId Collab.) REFID=54431
FELIZARDO	12	PRL 108 201302	M. Felizardo <i>et al.</i>	(SIMPLE Collab.) REFID=54236
KIM	12	PRL 108 181301	S.C. Kim <i>et al.</i>	(KIMS Collab.) REFID=54232
AAD	11AG	NJP 13 053044	G. Aad <i>et al.</i>	(ATLAS Collab.) REFID=54009
AAD	11I	PL B698 353	G. Aad <i>et al.</i>	(ATLAS Collab.) REFID=16565
AAD	11S	PL B705 294	G. Aad <i>et al.</i>	(ATLAS Collab.) REFID=53851
AALSETH	11	PRL 106 131301	C.E. Aalseth <i>et al.</i>	(CoGeNT Collab.) REFID=16607
AALSETH	11A	PRL 107 141301	C.E. Aalseth <i>et al.</i>	(CoGeNT Collab.) REFID=53823
AALTONEN	11AF	PRL 107 181801	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=53833
AALTONEN	11M	PRL 106 171801	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=16445
ABAZOV	11I	PRL 107 011804	V. M. Abazov <i>et al.</i>	(D0 Collab.) REFID=16475
ABBASI	11C	PR D84 022004	R. Abbasi <i>et al.</i>	(IceCube Collab.) REFID=16533
ABRAMOWSKI	11	PRL 106 161301	A. Abramowski <i>et al.</i>	(HE.E.S.S. Collab.) REFID=16615
ACKERMANN	11	PRL 107 241302	M. Ackermann <i>et al.</i>	(Fermi-LAT Collab.) REFID=54028
AHLEN	11	PL B695 124	S. Ahlen <i>et al.</i>	(DMTPC Collab.) REFID=53566
AHMED	11	PR D83 112002	Z. Ahmed <i>et al.</i>	(CDMS Collab.) REFID=16609
AHMED	11A	PR D84 011102	Z. Ahmed <i>et al.</i>	(CDMS Collab.) REFID=16611
AHMED	11B	PRL 106 131302	Z. Ahmed <i>et al.</i>	(CDMS Collab.) REFID=16613
AJELLO	11	PR D84 032007	M. Ajello <i>et al.</i>	(Fermi-LAT) REFID=53715
ANGLE	11	PRL 107 051301	J. Angle <i>et al.</i>	(XENON10 Collab.) REFID=16659
Also		PRL 110 249901 (errat)	J. Angle <i>et al.</i>	(XENON10 Collab.) REFID=55000
APRILE	11	PR D84 052003	E. Aprile <i>et al.</i>	(XENON100 Collab.) REFID=53793
APRILE	11A	PR D84 061101	E. Aprile <i>et al.</i>	(XENON100 Collab.) REFID=53794
APRILE	11B	PRL 107 131302	E. Aprile <i>et al.</i>	(XENON100 Collab.) REFID=53821
ARMENGAUD	11	PL B702 329	E. Armengaud <i>et al.</i>	(EDELWEISS II Collab.) REFID=16711
BEHNKE	11	PRL 106 021303	E. Behnke <i>et al.</i>	(COUPP Collab.) REFID=53601
CHATRCHYAN	11C	JHEP 1106 026	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=16351
CHATRCHYAN	11U	PRL 107 201804	S. Chatrchyan <i>et al.</i>	(CMS Collab.) REFID=53840
GERINGER-SA...	11	PRL 107 241303	A. Geringer-Sameth, S.M. Koushiappas	REFID=53954
HORN	11	PL B705 471	M. Horn <i>et al.</i>	(ZEPLIN-III Collab.) REFID=53870
TANAKA	11	APJ 742 78	T. Tanaka <i>et al.</i>	(Super-Kamiokande Collab.) REFID=54074
AAD	10	PRL 105 161801	G. Aad <i>et al.</i>	(ATLAS Collab.) REFID=53477
AALTONEN	10AF	PR D82 052005	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=53618
ABBASI	10	PR D81 057101	R. Abbasi <i>et al.</i>	(IceCube Collab.) REFID=53392
AHMED	10	SCI 327 1619	Z. Ahmed <i>et al.</i>	(CDMS II Collab.) REFID=53691
AKERIB	10	PR D82 122004	D.S. Akerib <i>et al.</i>	(CDMS-II Collab.) REFID=53599
AKIMOV	10	PL B692 180	D.Yu. Akimov <i>et al.</i>	(ZEPLIN-III Collab.) REFID=53423
APRILE	10	PRL 105 131302	E. Aprile <i>et al.</i>	(XENON100 Collab.) REFID=53489
ARMENGAUD	10	PL B687 294	E. Armengaud <i>et al.</i>	(EDELWEISS II Collab.) REFID=53281
FELIZARDO	10	PRL 105 211301	M. Felizardo <i>et al.</i>	(The SIMPLE Collab.) REFID=53463
KHACHATRY...	10	PRL 105 211801	V. Khachatryan <i>et al.</i>	(CMS Collab.) REFID=53465
Also		PRL 106 029902	V. Khachatryan <i>et al.</i>	(CMS Collab.) REFID=53629
MIUCHI	10	PL B686 11	K. Miuchi <i>et al.</i>	(NEWAGE Collab.) REFID=53307
AALTONEN	09AF	PR D80 011102	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=52948
AALTONEN	09G	PR D79 052004	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=52801
AALTONEN	09Z	PRL 103 021802	T. Aaltonen <i>et al.</i>	(CDF Collab.) REFID=52931
ABAZOV	09M	PRL 102 161802	V.M. Abazov <i>et al.</i>	(D0 Collab.) REFID=52866
ABBASI	09B	PRL 102 201302	R. Abbasi <i>et al.</i>	(IceCube Collab.) REFID=52847
AHMED	09	PRL 102 011301	Z. Ahmed <i>et al.</i>	(CDMS Collab.) REFID=52613
ANGLE	09	PR D80 115005	J. Angle <i>et al.</i>	(XENON10 Collab.) REFID=54072
ANGLOHER	09	ASP 31 270	G. Angloher <i>et al.</i>	(CRESST Collab.) REFID=52769
ARCHAMBAU..	09	PL B682 185	S. Archambault <i>et al.</i>	(PICASSO Collab.) REFID=53085
LEBEDENKO	09A	PRL 103 151302	V.N. Lebedenko <i>et al.</i>	(ZEPLIN-III Collab.) REFID=53093
LIN	09	PR D79 061101	S.T. Lin <i>et al.</i>	(TEXONO Collab.) REFID=52824
AALSETH	08	PRL 101 251301	C.E. Aalseth <i>et al.</i>	(CoGeNT Collab.) REFID=52626
Also		PRL 102 109903 (errat)	C.E. Aalseth <i>et al.</i>	(CoGeNT Collab.) REFID=54073
ANGLE	08A	PRL 101 091301	J. Angle <i>et al.</i>	(XENON10 Collab.) REFID=52446
BEDNYAKOV	08	PAN 71 111	V.A. Bednyakov, H.P. Klapdor-Kleingrothaus, I.V. Krivosheina	REFID=52471;ERROR=1

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ALNER	07	PL B653 161	G.J. Alner <i>et al.</i>	(ZEPLIN-II Collab.)	REFID=51878
LEE	07A	PRL 99 091301	H.S. Lee <i>et al.</i>	(KIMS Collab.)	REFID=51919
MUCHI	07	PL B654 58	K. Miuchi <i>et al.</i>		REFID=52025
AKERIB	06	PR D73 011102	D.S. Akerib <i>et al.</i>	(CDMS Collab.)	REFID=51018
SHIMIZU	06A	PL B633 195	Y. Shimizu <i>et al.</i>		REFID=51200
AKERIB	05	PR D72 052009	D.S. Akerib <i>et al.</i>	(CDMS Collab.)	REFID=50906
ALNER	05	PL B616 17	G.J. Alner <i>et al.</i>	(UK Dark Matter Collab.)	REFID=50608
BARNABE-HE..	05	PL B624 186	M. Barnabe-Heider <i>et al.</i>	(PICASSO Collab.)	REFID=50874
BENOIT	05	PL B616 25	A. Benoit <i>et al.</i>	(EDELWEISS Collab.)	REFID=50609
GIRARD	05	PL B621 233	T.A. Girard <i>et al.</i>	(SIMPLE Collab.)	REFID=50680
GIULIANI	05	PRL 95 101301	F. Giuliani		REFID=50560
GIULIANI	05A	PR D71 123503	F. Giuliani, T.A. Girard		REFID=50669
KLAPDOR-K...	05	PL B609 226	H.V. Klapdor-Kleingrothaus, I.V. Krivosheina, C. Tomei		REFID=50595;ERROR=2
AKTAS	04C	EPJ C36 413	A. Atkas <i>et al.</i>	(H1 Collab.)	REFID=50148
GIULIANI	04	PL B588 151	F. Giuliani, T.A. Girard		REFID=49900
GIULIANI	04A	PRL 93 161301	F. Giuliani		REFID=50254
MUCHI	03	ASP 19 135	K. Miuchi <i>et al.</i>		REFID=49319
TAKEDA	03	PL B572 145	A. Takeda <i>et al.</i>		REFID=49551
ANGLOHER	02	ASP 18 43	G. Angloher <i>et al.</i>	(CRESST Collab.)	REFID=49046
BELLI	02	PR D66 043503	P. Belli <i>et al.</i>		REFID=48986
BERNABEI	02C	EPJ C23 61	R. Bernabei <i>et al.</i>	(DAMA Collab.)	REFID=48974
GREEN	02	PR D66 083003	A.M. Green		REFID=49069
JAVORSEK	02	PR D65 072003	D. Javorsek II <i>et al.</i>		REFID=48882
BAUDIS	01	PR D63 022001	L. Baudis <i>et al.</i>	(Heidelberg-Moscow Collab.)	REFID=47899
JAVORSEK	01	PR D64 012005	D. Javorsek II <i>et al.</i>		REFID=48180
JAVORSEK	01B	PRL 87 231804	D. Javorsek II <i>et al.</i>		REFID=48439
SMITH	01	PR D64 043502	D. Smith, N. Weiner		REFID=49225
ULLIO	01	JHEP 0107 044	P. Ullio, M. Kamionkowski, P. Vogel		REFID=49023
ABBIENDI	00D	EPJ C13 197	G. Abbiendi <i>et al.</i>	(OPAL Collab.)	REFID=47464
AMBROSIO	00B	EPJ C13 453	M. Ambrosio <i>et al.</i>	(MACRO Collab.)	REFID=47625
BENOIT	00	PL B479 8	A. Benoit <i>et al.</i>	(EDELWEISS Collab.)	REFID=47618
BERNABEI	00D	NJP 2 15	R. Bernabei <i>et al.</i>	(DAMA Collab.)	REFID=49104
COLLAR	00	PRL 85 3083	J.I. Collar <i>et al.</i>	(SIMPLE Collab.)	REFID=47781
ABE	99F	PRL 82 2038	F. Abe <i>et al.</i>	(CDF Collab.)	REFID=46728
AMBROSIO	99	PR D60 082002	M. Ambrosio <i>et al.</i>	(Macro Collab.)	REFID=47231
BERNABEI	99	PL B450 448	R. Bernabei <i>et al.</i>	(DAMA Collab.)	REFID=46823
BERNABEI	99D	PRL 83 4918	R. Bernabei <i>et al.</i>	(DAMA Collab.)	REFID=47316
BRHLIK	99	PL B464 303	M. Brhlik, L. Roszkowski		REFID=47239
DERBIN	99	PAN 62 1886	A.V. Derbin <i>et al.</i>		REFID=47313
		Translated from YAF 62 2034.			
ACKERSTAFF	98P	PL B433 195	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)	REFID=46077
KLIMENKO	98	JETPL 67 875	A.A. Klimenko <i>et al.</i>		REFID=46039
		Translated from ZETFP 67 835.			
ABE	97G	PR D55 R5263	F. Abe <i>et al.</i>	(CDF Collab.)	REFID=45343
ABREU	97D	PL B396 315	P. Abreu <i>et al.</i>	(DELPHI Collab.)	REFID=45316
ACKERSTAFF	97B	PL B391 210	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)	REFID=45244
ADAMS	97B	PRL 79 4083	J. Adams <i>et al.</i>	(FNAL KTeV Collab.)	REFID=45722
BARATE	97K	PL B405 379	R. Barate <i>et al.</i>	(ALEPH Collab.)	REFID=45551
SARSA	97	PR D56 1856	M.L. Sarsa <i>et al.</i>	(ZARA)	REFID=45606
ALESSAND...	96	PL B384 316	A. Alessandrello <i>et al.</i>	(MILA, MILAI, SASSO)	REFID=44900
BELLI	96	PL B387 222	P. Belli <i>et al.</i>	(DAMA Collab.)	REFID=44922
Also		PL B389 783 (erratum)	P. Belli <i>et al.</i>	(DAMA Collab.)	REFID=45239
BELLI	96C	NC 19C 537	P. Belli <i>et al.</i>	(DAMA Collab.)	REFID=45562
BERNABEI	96	PL B389 757	R. Bernabei <i>et al.</i>	(DAMA Collab.)	REFID=45075
COLLAR	96	PRL 76 331	J.I. Collar	(SCUC)	REFID=44752
SARSA	96	PL B386 458	M.L. Sarsa <i>et al.</i>	(ZARA)	REFID=44919
Also		PR D56 1856	M.L. Sarsa <i>et al.</i>	(ZARA)	REFID=45606
SMITH	96	PL B379 299	P.F. Smith <i>et al.</i>	(RAL, SHEF, LOIC+)	REFID=44868
SNOWDEN-...	96	PRL 76 332	D.P. Snowden-Ifft, E.S. Freeman, P.B. Price	(UCB)	REFID=44753
AKERS	95R	ZPHY C67 203	R. Akers <i>et al.</i>	(OPAL Collab.)	REFID=44370
GALLAS	95	PR D52 6	E. Gallas <i>et al.</i>	(MSU, FNAL, MIT, FLOR)	REFID=44291
GARCIA	95	PR D51 1458	E. Garcia <i>et al.</i>	(ZARA, SCUC, PNL)	REFID=44143
QUENBY	95	PL B351 70	J.J. Quenby <i>et al.</i>	(LOIC, RAL, SHEF+)	REFID=44278
SNOWDEN-...	95	PRL 74 4133	D.P. Snowden-Ifft, E.S. Freeman, P.B. Price	(UCB)	REFID=44258
Also		PRL 76 331	J.I. Collar	(SCUC)	REFID=44752
Also		PRL 76 332	D.P. Snowden-Ifft, E.S. Freeman, P.B. Price	(UCB)	REFID=44753
BECK	94	PL B336 141	M. Beck <i>et al.</i>	(MPIH, KIAE, SASSO)	REFID=43965
RAM	94	PR D49 3120	S. Ram <i>et al.</i>	(TELA, TRIU)	REFID=43855
ABE	93G	PRL 71 2542	F. Abe <i>et al.</i>	(CDF Collab.)	REFID=43512
ASTONE	93	PR D47 4770	P. Astone <i>et al.</i>	(ROMA, ROMAI, CATA, FRAS)	REFID=43329
BUSKULIC	93C	PL B303 198	D. Buskulic <i>et al.</i>	(ALEPH Collab.)	REFID=43295
YAMAGATA	93	PR D47 1231	T. Yamagata, Y. Takamori, H. Utsunomiya	(KONAN)	REFID=43102
ABE	92J	PR D46 R1889	F. Abe <i>et al.</i>	(CDF Collab.)	REFID=42100
AHLEN	92	PRL 69 1860	S.P. Ahlen <i>et al.</i>	(MACRO Collab.)	REFID=42185
BACCI	92	PL B293 460	C. Bacci <i>et al.</i>	(Beijing-Roma-Saclay Collab.)	REFID=42226
VERKERK	92	PRL 68 1116	P. Verkerk <i>et al.</i>	(ENSP, SACL, PAST)	REFID=41964
AKESSON	91	ZPHY C52 219	T. Akesson <i>et al.</i>	(HELIOS Collab.)	REFID=41739
NAKAMURA	91	PL B263 529	S. Nakamura <i>et al.</i>		REFID=48079
ORITO	91	PRL 66 1951	S. Orito <i>et al.</i>		REFID=41478
REUSSER	91	PL B255 143	D. Reusser <i>et al.</i>	(ICEPP, WASCR, NIHO, ICRR)	REFID=41453
ADACHI	90C	PL B244 352	I. Adachi <i>et al.</i>	(NEUC, CIT, PSI)	REFID=41322
ADACHI	90E	PL B249 336	I. Adachi <i>et al.</i>	(TOPAZ Collab.)	REFID=41410
AKRAWY	90O	PL B252 290	M.Z. Akrawy <i>et al.</i>	(OPAL Collab.)	REFID=41425
HEMMICK	90	PR D41 2074	T.K. Hemmick <i>et al.</i>	(ROCH, MICH, OHIO+)	REFID=41245
SAITO	90	PRL 65 2094	T. Saito <i>et al.</i>	(ICRR, KOBE)	REFID=41713
NAKAMURA	89	PR D39 1261	T.T. Nakamura <i>et al.</i>	(KYOT, TMTC)	REFID=40833
NORMAN	89	PR D39 2499	E.B. Norman <i>et al.</i>	(LBL)	REFID=40841
BERNSTEIN	88	PR D37 3103	R.M. Bernstein <i>et al.</i>	(STAN, WISC)	REFID=40673
CALDWELL	88	PRL 61 510	D.O. Caldwell <i>et al.</i>	(UCSB, UCB, LBL)	REFID=40752
LIU	88	PRL 61 271	G. Liu, B. Barish		REFID=48116
BARISH	87	PR D36 2641	B.C. Barish, G. Liu, C. Lane	(CIT)	REFID=40495
NORMAN	87	PRL 58 1403	E.B. Norman, S.B. Gaze, D.A. Bennett	(LBL)	REFID=40168
BADIER	86	ZPHY C31 21	J. Badier <i>et al.</i>	(NA3 Collab.)	REFID=10622
MINCER	85	PR D32 541	A. Mincer <i>et al.</i>	(UMD, GMAS, NSF)	REFID=12660

NAKAMURA	85	PL 161B 417	K. Nakamura <i>et al.</i>	(KEK, INUS)	REFID=12661
THRON	85	PR D31 451	J.L. Thron <i>et al.</i>	(YALE, FNAL, IOWA)	REFID=12663
SAKUYAMA	83B	LNC 37 17	H. Sakuyama, N. Suzuki	(MEIS)	REFID=12644
Also		LNC 36 389	H. Sakuyama, K. Watanabe	(MEIS)	REFID=12645
Also		NC 78A 147	H. Sakuyama, K. Watanabe	(MEIS)	REFID=12646
Also		NC 6C 371	H. Sakuyama, K. Watanabe	(MEIS)	REFID=12647
BHAT	82	PR D25 2820	P.N. Bhat <i>et al.</i>	(TATA)	REFID=12622
KINOSHITA	82	PRL 48 77	K. Kinoshita, P.B. Price, D. Fryberger	(UCB+)	REFID=12388
MARINI	82	PR D26 1777	A. Marini <i>et al.</i>	(FRAS, LBL, NWES, STAN+)	REFID=12625
SMITH	82B	NP B206 333	P.F. Smith <i>et al.</i>	(RAL)	REFID=12627
KINOSHITA	81B	PR D24 1707	K. Kinoshita, P.B. Price	(UCB)	REFID=12394
LOSECCO	81	PL 102B 209	J.M. LoSecco <i>et al.</i>	(MICH, PENN, BNL)	REFID=10605
ULLMAN	81	PRL 47 289	J.D. Ullman	(LEHM, BNL)	REFID=12395
YOCK	81	PR D23 1207	P.C.M. Yock	(AUCK)	REFID=12617
BARTEL	80	ZPHY C6 295	W. Bartel <i>et al.</i>	(JADE Collab.)	REFID=12158
BUSSIERE	80	NP B174 1	A. Bussiere <i>et al.</i>	(BGNA, SACL, LAPP)	REFID=10599
YOCK	80	PR D22 61	P.C.M. Yock	(AUCK)	REFID=12611
ARMITAGE	79	NP B150 87	J.C.M. Armitage <i>et al.</i>	(CERN, DARE, FOM+)	REFID=10593
BOZZOLI	79	NP B159 363	W. Bozzoli <i>et al.</i>	(BGNA, LAPP, SACL+)	REFID=12240
GOODMAN	79	PR D19 2572	J.A. Goodman <i>et al.</i>	(UMD)	REFID=12606
SMITH	79	NP B149 525	P.F. Smith, J.R.J. Bennett	(RHEL)	REFID=12607
BHAT	78	PRAM 10 115	P.N. Bhat, P.V. Ramana Murthy	(TATA)	REFID=12591
CARROLL	78	PRL 41 777	A.S. Carroll <i>et al.</i>	(BNL, PRIN)	REFID=12592
CUTTS	78	PRL 41 363	D. Cutts <i>et al.</i>	(BROW, FNAL, ILL, BARI+)	REFID=12593
VIDAL	78	PL 77B 344	R.A. Vidal <i>et al.</i>	(COLU, FNAL, STON+)	REFID=12599
ALEKSEEV	76	SJNP 22 531	G.D. Alekseev <i>et al.</i>	(JINR)	REFID=12576
		Translated from YAF 22 1021.			
ALEKSEEV	76B	SJNP 23 633	G.D. Alekseev <i>et al.</i>	(JINR)	REFID=12577
		Translated from YAF 23 1190.			
BALDIN	76	SJNP 22 264	B.Y. Baldin <i>et al.</i>	(JINR)	REFID=12260
		Translated from YAF 22 512.			
BRIATORE	76	NC 31A 553	L. Briatore <i>et al.</i>	(LCGT, FRAS, FREIB)	REFID=12261
GUSTAFSON	76	PRL 37 474	H.R. Gustafson <i>et al.</i>	(MICH)	REFID=12580
ALBROW	75	NP B97 189	M.G. Albrow <i>et al.</i>	(CERN, DARE, FOM+)	REFID=12263
FRANKEL	75	PR D12 2561	S. Frankel <i>et al.</i>	(PENN, FNAL)	REFID=12572
JOVANOV...	75	PL 56B 105	J.V. Jovanovich <i>et al.</i>	(MANI, AACH, CERN+)	REFID=12266
YOCK	75	NP B86 216	P.C.M. Yock	(AUCK, SLAC)	REFID=12575
APPEL	74	PRL 32 428	J.A. Appel <i>et al.</i>	(COLU, FNAL)	REFID=12567
FRANKEL	74	PR D9 1932	S. Frankel <i>et al.</i>	(PENN, FNAL)	REFID=12568
YOCK	74	NP B76 175	P.C.M. Yock	(AUCK)	REFID=12569
ALPER	73	PL 46B 265	B. Alper <i>et al.</i>	(CERN, LIVP, LUND, BOHR+)	REFID=12272
LEIPUNER	73	PRL 31 1226	L.B. Leipuner <i>et al.</i>	(BNL, YALE)	REFID=12275
DARDO	72	NC 9A 319	M. Dardo <i>et al.</i>	(TORI)	REFID=12281
TONWAR	72	JPA 5 569	S.C. Tonwar, S. Naranan, B.V. Sreekantan	(TATA)	REFID=12283
ANTIPOV	71B	NP B31 235	Y.M. Antipov <i>et al.</i>	(SERP)	REFID=12561
ANTIPOV	71C	PL 34B 164	Y.M. Antipov <i>et al.</i>	(SERP)	REFID=12560
BINON	69	PL 30B 510	F.G. Binon <i>et al.</i>	(SERP)	REFID=12559
BJORNBOE	68	NC B53 241	J. Bjornboe <i>et al.</i>	(BOHR, TATA, BERN+)	REFID=12303
JONES	67	PR 164 1584	L.W. Jones	(MICH, WISC, LBL, UCLA, MINN+)	REFID=12557
DORFAN	65	PRL 14 999	D.E. Dorfan <i>et al.</i>	(COLU)	REFID=12330